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Voltages to suit customers' requirements.

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19 cwt. 970 kg.

Overarm adjustment from column face, maximum	22"
Overarm adjustment from column face, minimum	5½"
Spindle nose to top of table, maximum	19"
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Face of column to centre line of T slot in table, maximum	17"
Face of column to centre line of T slot in table, minimum	5"

Illustrations and specifications not binding as to detail

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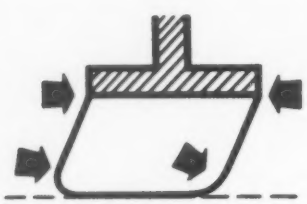
PULLEY WHEEL COVERINGS



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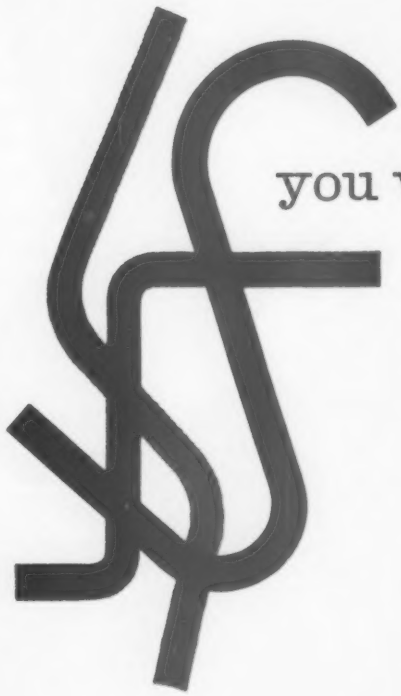

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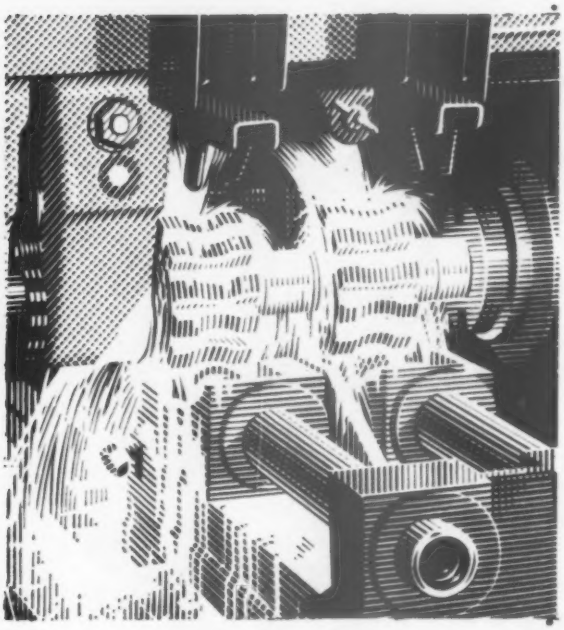

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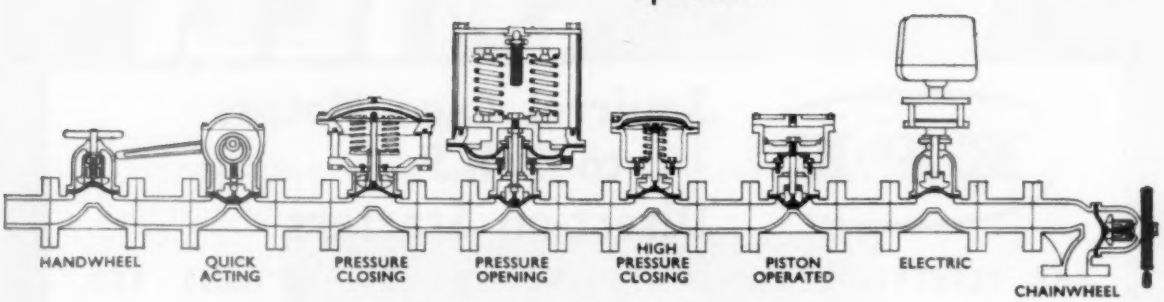

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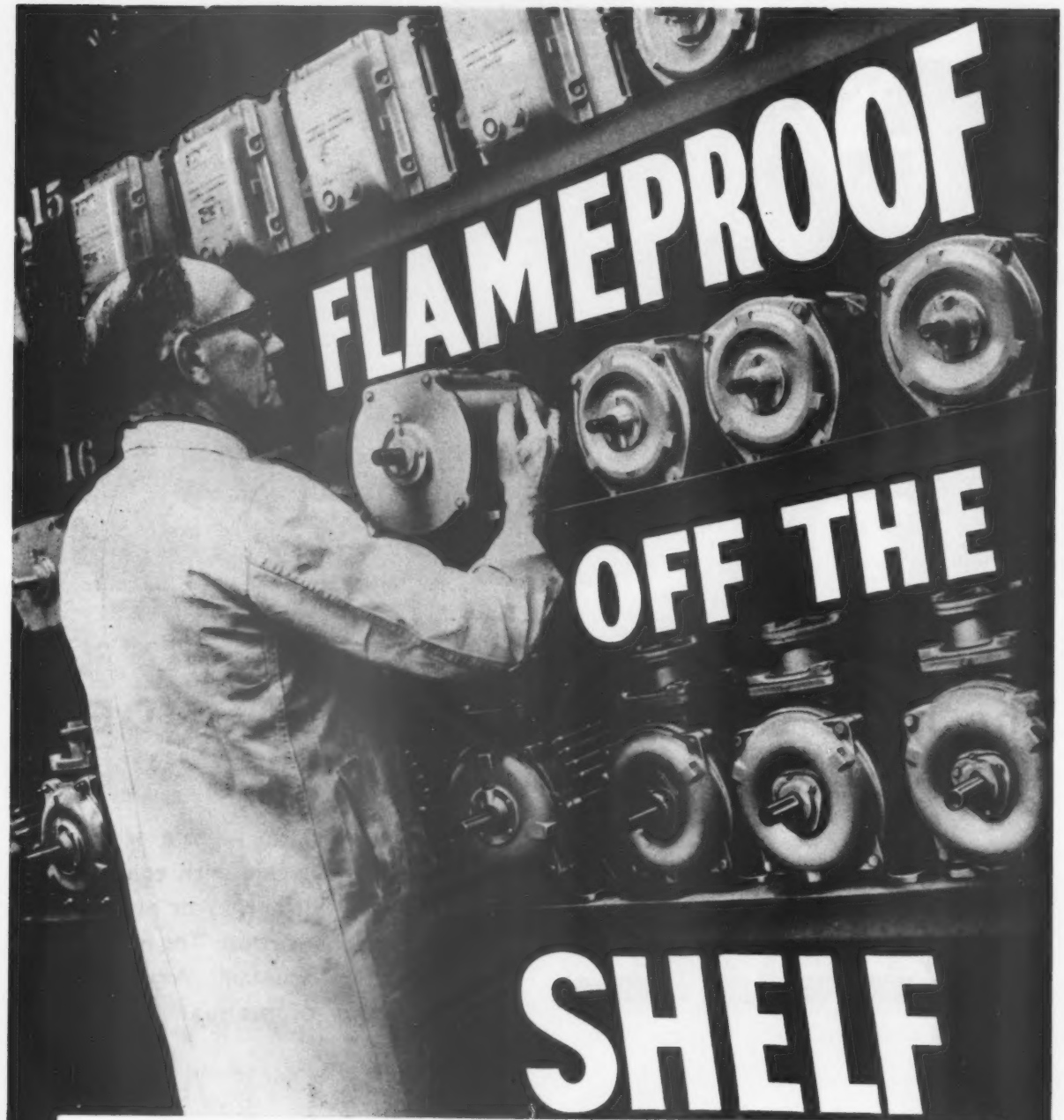

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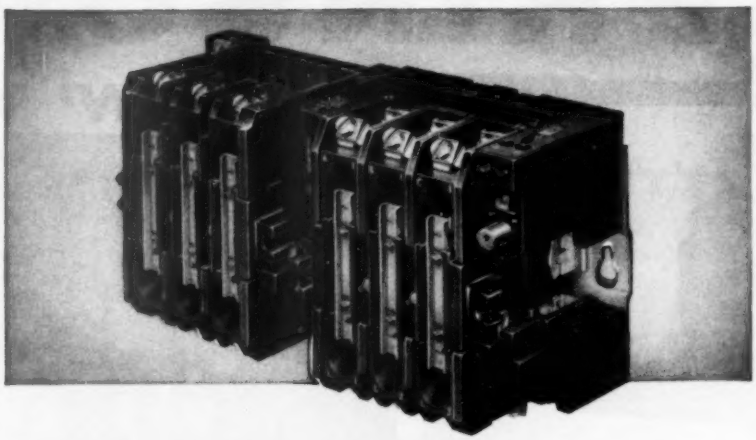

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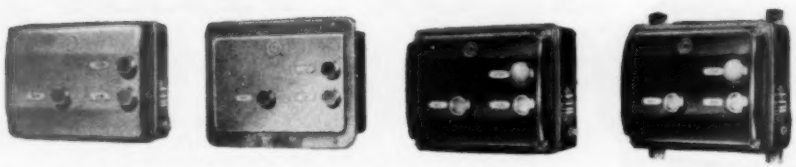

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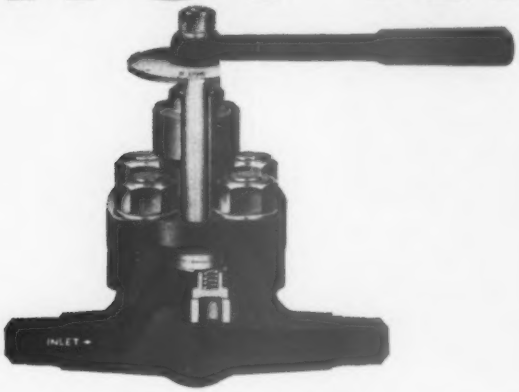

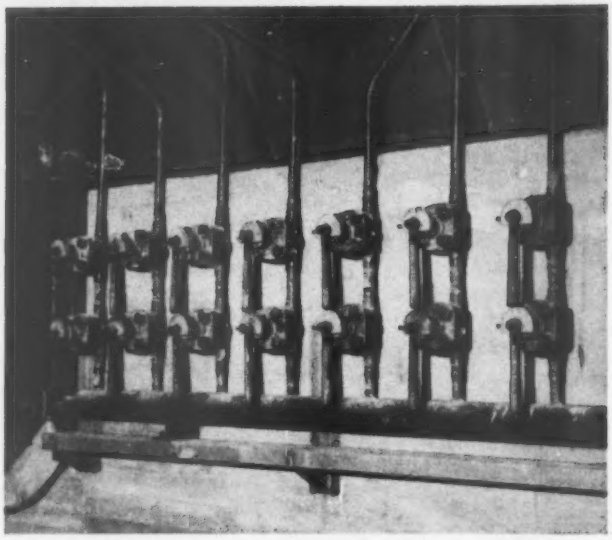

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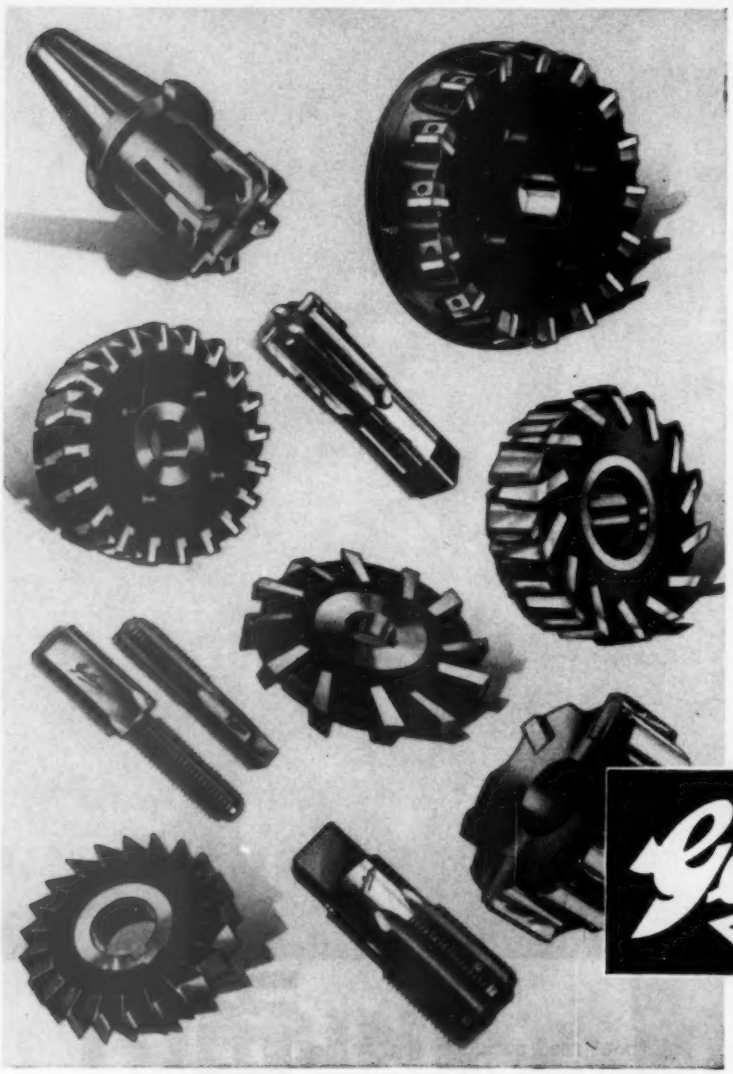

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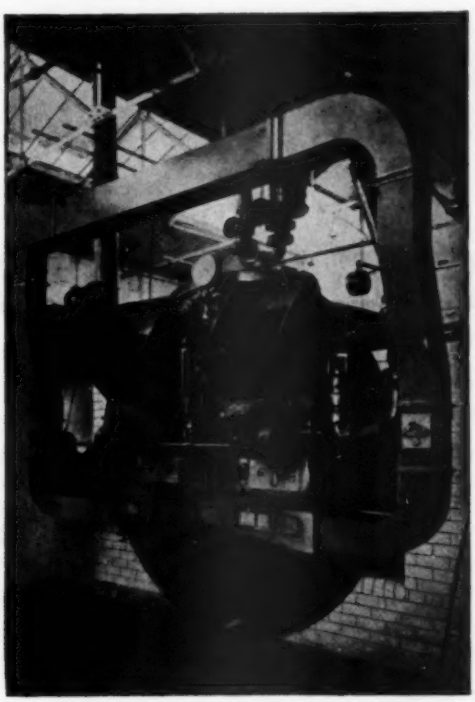

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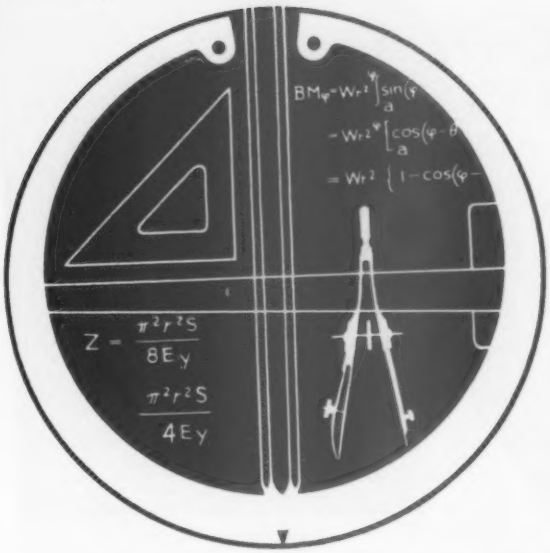
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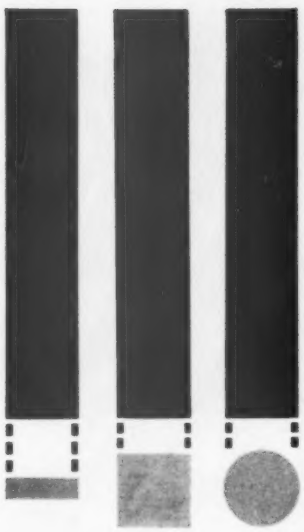

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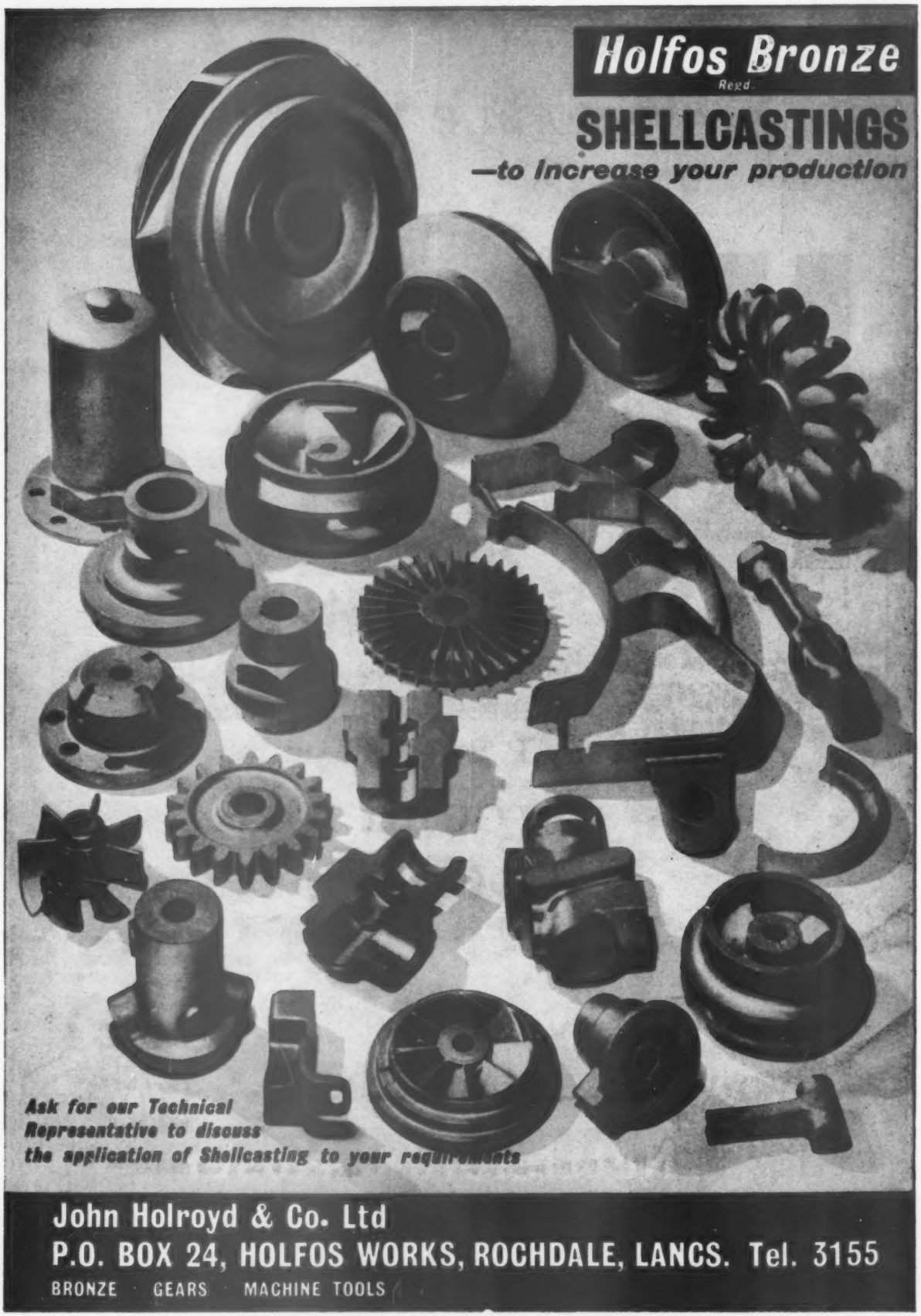
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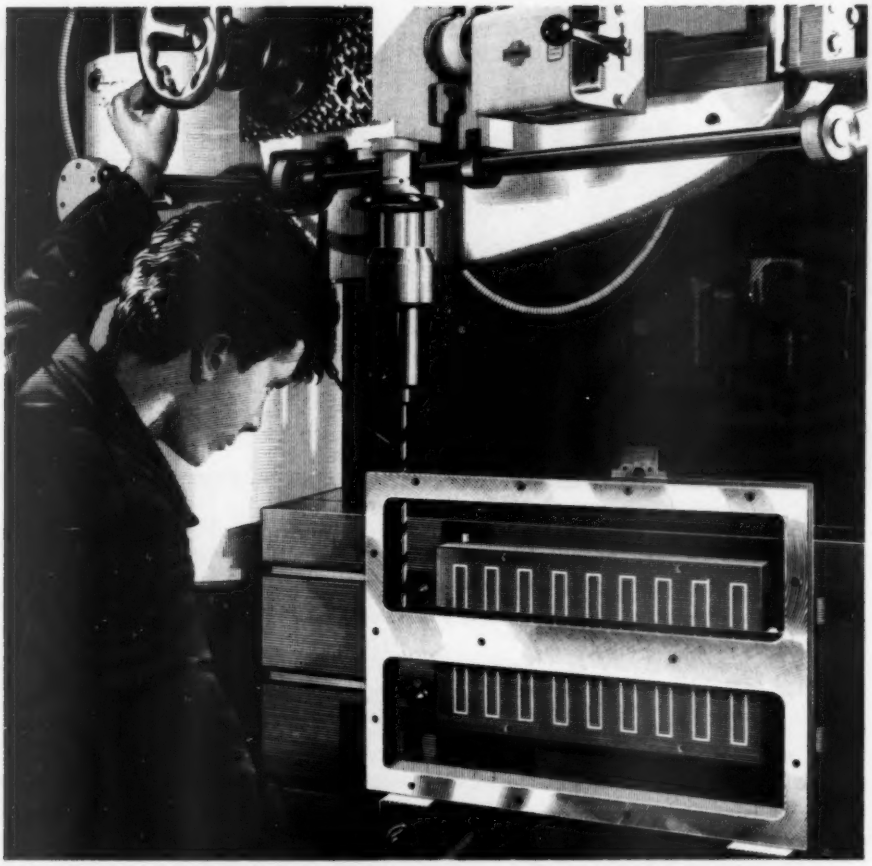

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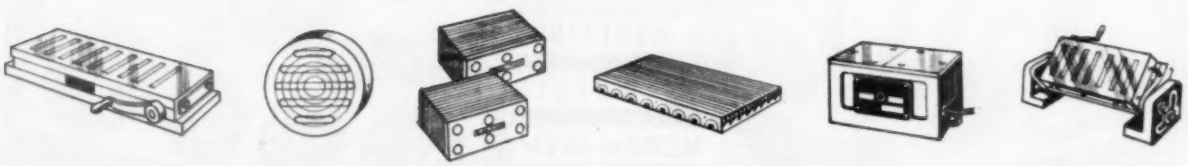

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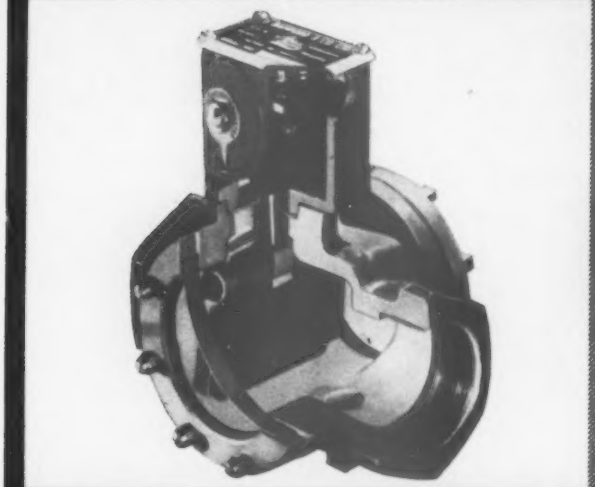

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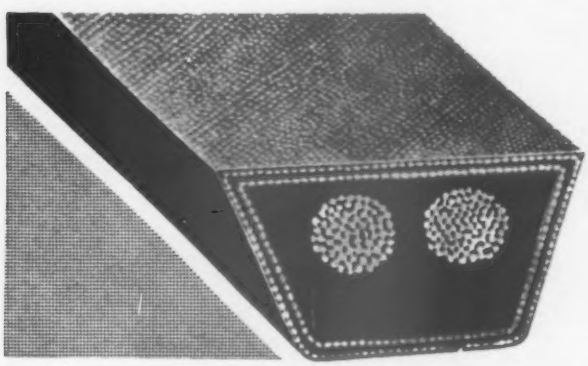

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Mechanical World

AND ENGINEERING RECORD

Vol. 142 AUGUST, 1962 Number 3517

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Mechanical World —— August 1962

Design Refinement

THE final test of a manufactured product lies in the hands of the customer, who experiences the service given by the product and suffers from any deficiencies it may have.

Any product of an engineering kind has some function to perform and how well it does it is a first criterion. How long it continues to perform its function without depreciation or breakdown is a second, and the cost of the function to the consumer and the facility with which the product may be given necessary attention are a third and fourth. Others could be separated from this short list but the enumeration is not one of priorities: to the user all are important and there is no reason today why a deficiency in one attribute should be accepted because of superlative quality in another. This means fundamentally that design should be in all respects complete and, particularly, fully refined.

Design usually starts off with an idea for a means for carrying out some operation. Except in the case of a major invention, realization of the object is usually reached by the expert application of mechanical and related principles and methods. But it is very seldom indeed that the first attempt is the best, though in actual fact it so often blankets the vision of those immediately concerned in the project that it is not until snags appear in manufacture and use that development is resumed. Thereafter refinement takes place until, given a continuing favourable market, the ultimate possibilities of the design are attained.

In contrast to this, refinement in the design stage is not by any means unknown. At the same time it is far from universal. It is obtained by the application of scientific method—all the way from material to the condition of the product after years of use—and all this (or most of it) before it finally leaves the drawing board. The procedure lies in giving careful consideration to each process, from pattern-making and toolmaking onwards, examining exactly what will be done and why, and examining all the ways in which it could be done and finally finding the most appropriate and economical in terms of the useful life-performance of the product.

This quickly gets rid of the fog (it also gets rid of some useless products before too much is spent on them). It reduces details to a minimum, makes for easy and cheap manufacture (particularly assembly) and ensures automatically a pleasing form and a desirable and hygienic finish. And it inevitably means, since something good for its purpose is produced at the minimum cost, that success is assured.

LOG SHEET

Die Shear Line

The first steel stockholders in this country to install a McKaymatic die shear line are P. B. Grigg & Sons Limited, Murdoch Road, Bilston, Staffs. This compact installation enables them to provide customers with sheets of any length upwards of 12 in. as changing the sheet length requires only the operation of a maximum of five counter switches on the control console. Owing to the high output (up to 180 ft per min) it is also possible to process customers' own material. This particular line will handle stock up to 48 in. wide and up to 0·072 in. thick at 40,000 psi yield strength (0·102 in. thick at 20,000 psi).

From the 10 ton capacity expanding mandrel coil holder the strip is passed through a 17-roll leveller with 1½ in. dia work rolls and 5 back up rolls at top and bottom. These impart flatness to ferrous and non-ferrous sheet approaching that obtained by stretcher levelling. Each bank of back up rolls can be adjusted to regulate work roll pressure for complete control of sheet flatness. Visual indicators are provided to show roll bank and back up roll positions.

The lower exit roll is driven only by friction of the material. This roll, which is exactly 20 in. circumference drives a pulse generator which transmits signals to a transistorized plug board counter with five decades. This triggers two successive relays, one to initiate lateral motion of the flying shear until it matches the material speed and the second to actuate the air clutch for the cutting action. The very high speed of the shear provides good length accuracy and enables the signal actuating the clutch to be used also as the datum line for the succeeding sheet. Maximum travel of the 15 ton capacity flying shear is 16 in. of which 3 in. are required to accelerate to the material speed, and a further 3 in. for deceleration.

Sheet metal from the coil is flattened and cut to any length at high speed on this machine. Length to be cut is set instantly on the console.

The mast of this Yale Battery electric fork lift truck was changed in 9 min at the demonstration of Yale equipment on Merseyside recently. Taking the strain is the new Yale 10,000 lb pneumatic diesel fork lift truck with a 72 in. goose neck boom attachment.

Port Mechanical Handling

Representatives of master porters, master stevedoring companies and shipping lines attended a demonstration of Yale mechanical handling equipment on Merseyside recently. This was the first demonstration of this kind to be held on the dock side under working conditions. Growing competition from world markets is emphasizing the need for the speeding of export cargoes and Port Authorities are realizing the necessity of mechanization. Included in the range of Yale equipment demonstrated were battery electric fork lift tricks (K51 series) pneumatic tyred and cushion tyred diesel fork lift trucks (DP51 & D51 series) an L.P.G. fork lift truck, the new 10,000 lb fork lift truck with 72 in. goose-neck boom attachment, the new Yale Junior tractor, Worksavers and a Yale 204 Trojan tractor shovel.

200-MW Turbine

Work is proceeding on the installation of the first of two 200-MW turbo-generators which G.E.C. (Engineering) Limited is supplying to Kincardine-B generating station. The set is due to be commissioned towards the end of the year. Turbine stop valve conditions are 2350 psi, 1050° F with reheat to 1000° F and condensing to a vacuum of 29 in. Hg. When commissioned it will be the largest turbo-generator in operation in Scotland.

The high-pressure rotor, intermediate-pressure rotor and both low-pressure rotors are solid forgings with discs, packings, couplings and, where relevant, thrust collars all forged integrally with the shafts. The first critical speed of the turbine is well above running speed and this contributes to the operational flexibility of the plant.

Blading throughout is designed on the vortex principle to give optimum efficiency at all radii. The 27½ in. long blades of the final stage on the low-pressure rotors are unique in contemporary practice in having concontinuous inverted arch shrouding and, in common with all G.E.C. designs, have no lacing wires. Each blade is rigidly attached to the rotor by means of forked roots and riveted transverse shear-pins.

Kennedy and Donkin are the consultants to the South of Scotland Electricity Board.

Park Gate's New Steelworks

Construction has started at Rotherham on the new £32 million steelworks on a 350-acre site for The Park Gate Iron and Steel Company Limited. The first of the two Kaldo basic oxygen steelmaking units, each of which is capable of producing 75 ton of steel every 90 min, will be commissioned in July 1963, and the second will be in operation by September of that year. Oxygen for these will be supplied from a 200 ton per day tonnage plant now being

installed. A 75 ton electric arc melting furnace to produce alloy and other high quality steels will be in production by August 1963.

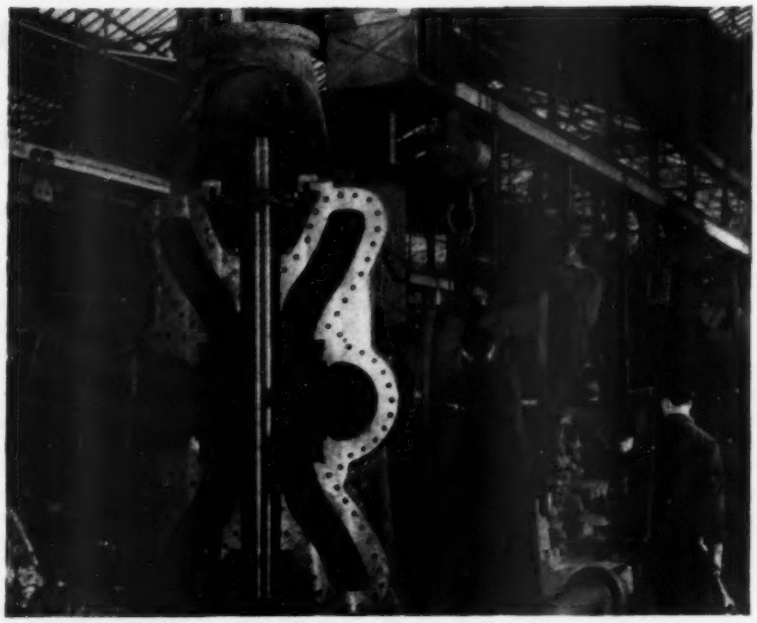
The project is designed to raise Park Gate's capacity from 425,000 to 800,000 ingot tons a year and the main item of expenditure is the provision of a new primary mill, incorporating fourteen ingot reheating furnaces, a reversing bloom mill and a six-stand continuous billet mill. Commissioning will start in June 1963, and the continuous narrow strip mill, designed to produce hot rolled strip up to 10 in. width and 2 gauge to 20 gauge thickness, will begin production in the fourth quarter of 1963.

Safety 'Oscar'

The 1962 Sir George Earle Trophy has been awarded by RoSPA to The Blue Circle Group of Cement Companies. Since 1920, when the Group was experiencing an average of 1000 lost-time accidents per year, the rate has been progressively reduced to less than 60 in 1961. With a labour force of some 10,000, this is a great achievement and is indicative of what can be accomplished by a safety-conscious and determined management/employee relationship.

The trophy is a magnificent silver Georgian inkstand awarded annually in open competition to any factory or other industrial organization which, in the opinion of the adjudicators, makes the most significant contribution to accident prevention.

HINKLEY POINT NUCLEAR POWER STATION.—Inside the reactor pressure vessel showing, at top, the King radial crane which has two arms radiating from a central post with supporting framework, each terminating in a hand operated travelling carriage running on a 40 ft dia circular gantry. The crane handles the graphite moderating blocks and components of the supporting floor and restraint beam sections which encircle the core.



WATER FOR THE DESERT.—Assembling one of three large water pumps for delivery to the Sudan Government. These pumps, being built by Mather & Platt Limited of Manchester, will be used in a scheme for increasing the acreage of sugar cultivation on the banks of the Blue Nile. Each of the pumps will handle 46,000 gpm.

Walking Dragline

One of the world's largest walking draglines, weighing 1850 ton and costing £900,000, is now at work at the Roxby opencast ironstone mine, Scunthorpe, for the Ore Mining Branch of The United Steel Companies Limited. The dragline, a RapieR W1800, is removing overburden from the ironstone bed. With its 303 ft fabricated boom and 25 cu yd bucket it strips up to 30 ton at each "bite", shifting its own weight of material every hour.

Ferodo at Caernarvon

The new Ferodo factory at Caernarvon is the company's first manufacturing expansion outside Chapel-en-le-Frith. It is on a 50-acre site close to the Menai Strait, with convenient road communications and ample local labour. Care has been taken in the design of the factory not to obtrude upon the amenities of the Snowdonia National Park, the site being lowered considerably and local materials used in the exposed wall cladding, the remainder being of a Cumberland stone colour and the paintwork a lime green with white trim. The factory is having a beneficial effect on the local economy. In contrast to the traditional local pattern of fluctuating seasonal employment, hundreds of new full-time jobs have been created.

Cold-Steel Extrusion

A 750-ton hydraulic press has been installed at the Triplex Fundamental Research Laboratory at Balsall Common, near Coventry. It will be used for basic investigation into the cold-extrusion process of steel and also serve to prove new tooling. The press has been designed and built by Weldall-Grigg Limited, a member of the Triplex Group.

The laboratory, under its director, Mr. K. J. B. Wolfe, is also working on cutting cost of extrusion lubrication, heat-treatment of tool steels, and slug or billet production.

Largest Single Axis Turbine

The largest single axis turbine yet to have been built in Great Britain has been run on test at the Trafford Park Works of Associated Electrical Industries Limited's Turbine Generator Division. It is the first of three 300 MW sets for West Thurrock Power Station and is of 4-cylinder construction, with one H.P., one I.P. and two double-flow L.P. cylinders. Steam is at 2,300 psig 1050° F re-heated to 1050° F before the I.P. cylinder. Both I.P. and H.P. cylinders are double-shell construction and steam flow is in opposite directions to minimize thrust. Each of the double flows has an AEI multi-exhaust final stage.

Cutting Devices for Narrow Webs

The knives used and the different mechanisms employed for their operation

By J. A. CUCKSON

THIS article describes the various cutting devices that have been used for severing thin flexible materials supplied in reel form, from which sheets of predetermined length are to be severed. Such cutting devices must be capable of making the cut should the web be fed intermittently or in a continuous manner. Each sheet should be accurate in length with the severed edge at right angles to the longitudinal edges of the web. The main aim is to reproduce the action of a pair of hand scissors whereby the cutting point moves progressively from one edge of the web to other; although there are other cases, when cutting webs say 1½ in. wide, where the scissor action is not necessary, depending on the application.

Methods used

In the past eighty years of development of packing and wrapping machinery the choice of the cutting blades, their mounting and methods of operation can be placed under certain headings. The various firms keep to their own particular design but they closely follow the general descriptions given.

Types of knives

The general form of knife is as depicted in Fig 1. The scissor type is usually made of tool steel, hardened and ground with the cutting face hollow ground or relieved by approx 0·005/·010 in. and having a thickness of $\frac{1}{8}$ to $\frac{1}{4}$ in. The cutting edge varies between 5° to 30°, $\frac{1}{32}$ in. wide with a backing angle between 20° and 35° For some machines a normal type of safety razor blade has been incorporated in the design of the cutting device.

The rotary type of cutting device is made on more substantial proportions. For high speed rotary cutting of toffee wrappers the rotary blade will only need to cut wrappers 4 in. wide and may be made of ½ in. × ¼ in. section. Should the package be such that an 18 in. web width must be cut, then the section is increased to 1½ in. × ½ in. There is less tooling requirements for the knives.

Serrated blade

This takes various forms. The simplest of which is shown in Fig 2, where the serrated blade A is given a simple up and down action so that the sharp points of the blade puncture the material, and having started to cut, complete the separation of the sheet by the enlargement of the puncture sideways. In every case, the web must be drawn or held taut by means of clamps B while the blade A is passed into the narrow slot C in the base of the web supporting platform D.

Fig 3 shows the type of cutting device that has been in use for nearly 50 years on American machines for wrapping the familiar thin sticks of chewing gum. In Fig 3 the serrated blade A is fixed, but in this instance there is a cam driven swinging cutting blade B, which has a mating serrated cutting face.

Plain blade and swinging serrated blade

The type of cutting device in Fig 4 is used chiefly in conjunction with the class of wrapping machine that makes use of what is called self-measuring web feeds and was described in MECHANICAL WORLD, January 1958.

In such equipment the article to be wrapped is pushed into a waiting web of material then into the jaws of a carrier arm. The carrier arm then rises, and as the web is still under tension it curves to tighten the web around the contour of the article, except for that portion which forms the lap fold, which at this stage still forms part of the main reel of wrapping material. When the final position is reached, the web is placed under a slight extra tension in order that the last remaining portion of the wrapper can be cleanly cut and laid tightly across the base of the article.

Referring to Fig. 4 this shows the positions of the various associated parts at the point of severing the wrapper. The web W passes from the reel through the various tensioning and arresting devices and then passes over a continuously driven feed roller A. The amount of web draped in front of the article for the first part of the wrapping operation, also the length of the bottom lap, are determined by the action of the measuring roller B carried by the cam-driven arms C. At the proper time, the arms C bring the two rollers AB together in order to draw or measure a length of material to form the initial drape and to put additional tension

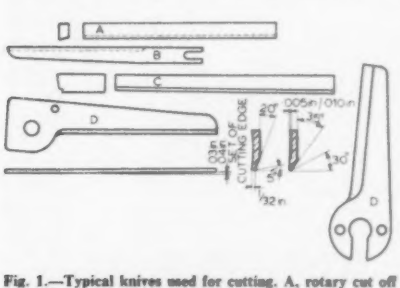


Fig. 1.—Typical knives used for cutting. A, rotary cut off knife; B, oscillating cut off knife; C, stationary knife for rotary knife; D, scissor type blades

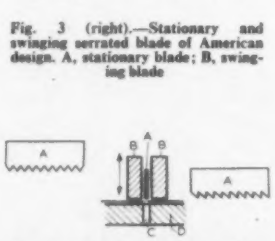
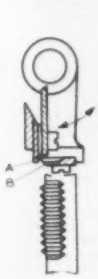


Fig. 2.—Types of serrated cutting knives commonly used on wrapping machines. A, serrated blade; B, clamps for web; C, slot for blade; D, web support platform

Fig. 3 (right).—Stationary and swinging serrated blade of American design. A, stationary blade; B, swinging blade



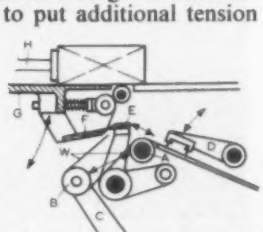


Fig. 4.—Type of cutter unit used on machines employing self-measuring paper feeds. A, web feed roller; B, web measuring roller; C, cam driven arm; D, web trap; E, cutting knife; F, fixed knife; G, article carrier arm; H, article ejector arm; W, web

on the web after it has been trapped at D just prior to the knife E, co-acting with the fixed blade F secured to the carrier G, severing the wrapper. Because the pivot point of the swinging cutter E is fixed, it is usual to provide some means of altering the timing relationship between the cutting knife E and the ejector H as this controls the length of the over lap fold at the base of the article. It is of further advantage if the adjustment for the over lap length can be carried out when the machine is in operation.

In Fig 5 there is a modification to the method just described. In this case the cutting knife A is fixed and the cutting action is similar to that described in connection with Fig 2. A rocking arm B is arranged at the appropriate time to present the narrow slot C to the underside of the tightened web and then to carry it into contact with the stationary cutting knife A to sever the wrapper. While this is taking place the rearward end of the arm B moves in the opposite direction and acts as the trap to prevent the web from falling backwards. A further modification is a design using a similar type of web feed but the serrated cut-off blade is actuated from a cam shaft and the slot is carried by the article carrier arm.

Severing by puncturing

In the example shown in Fig 6 the web feed is still of the self-measuring type in which the wrapper is severed at the completion of the wrapping operation. The fixed knife A is secured at a predetermined position at the delivery end of the machine. While the almost completely wrapped article B is being ejected, the web W is prevented from making contact with the serrated teeth of the fixed knife A because of the cam driven transfer platform and knife guard C. When the article has been enveloped in its wrapper for a greater distance than its circumference, the cam-driven roller and arm D move downwards to build tension in the web. As the article is being ejected from the carrier E by the pusher F, the transfer platform C is caused to move away and expose the teeth of the serrated blade A and so sever the wrapper from the continuous web of material

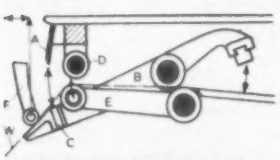


Fig. 5.—Web cutting device used on self-measuring web feeds. A, fixed cutting knife; B, web tension arm with slot; C, slot through which knife passes; D, web feed roller; E, cam driven arm carrying web measuring roller; F, roller arm provides tension to web, lays the final fold and drape of web; W, web

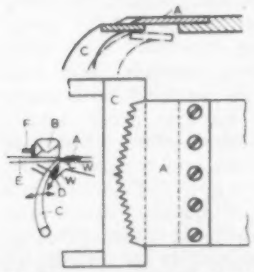


Fig. 6.—Severing by puncturing the taut web. A, fixed serrated blade; B, partially wrapped package; C, transfer platform and knife guard; D, tension roller; E, article carrier arm; F, ejector; W, web

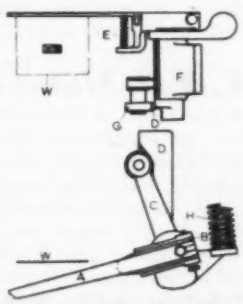


Fig. 7.—Cutting device used for narrow webs as used in wrapping sweets. A, moving knife; B, hinged knife holder; C, cam arm carrying knife; D, cam; E, compression spring to hold knife to stationary blade; F, adjustable bearing; G, cam roller; H, compression spring to take arm into contact with cam; W, web

Fig. 8.—Modified knife holder. A, moving knife; B, sprung knife holder and support

Fixed and hinged cutting blades

This type of arrangement is widely used. In it the stationary blade co-acts with a spring-urged guillotine blade or a blade carried in a pivoted housing and urged into contact by means of springs. Fig 7 shows a typical modern example. The moving or cutting blade A is carried by a pivoted holder B which is actuated by the cam-driven arm C and the open cam D. All knife actuating cams should be of the open or semi-positive type to minimise the results of accidents. The moving blade A is kept in shear with the fixed knife by means of a spring E. To compensate for the wrapping of different sizes of articles it is essential that the bearing F carrying the arm C be made adjustable in the direction of the web feed. In order to maintain contact with the cam D, the cam roller G may have to be made of such a length as to compensate for the range of adjustment necessary for the proposed sizes. In a modification of this, the holder may be arranged as in Fig 8 in which case the spindle carrying the holder may be capable of adjustment and the cam actuated linkages remain in a constant relationship.

Two moving blades

Cutting webs by means of two moving blades, giving a scissor-like action, is widely used on all types of wrapping machinery. Because of their self-cleaning action they are more suited to working with coated materials than are the simpler shear devices having a fixed and a moving blade. They do not tend to displace the web as much. As shown in Fig 9, the linkage takes a different form chiefly because space is at a premium in the machines in which it is used, and the size range of the machine calls for more frequent adjustment. The device is chiefly used in conjunction with a web feed that is drawn by gripper jaws, and the scissors must be opened wide enough to permit the jaws to pass through, and on occasion the operating linkage as well. The cutting blades should be so arranged that they can be easily removed for sharpening or replacement.

In Fig 9 the pivoted scissor blades A are directly coupled to an actuating piece B by means of the link arms C and D. Then timing and movement is controlled by a cam-driven link E. In a mechanism of this type

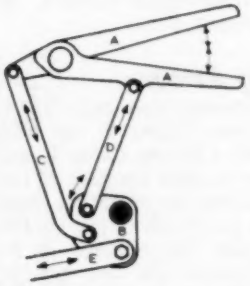


Fig. 9 (left).—Scissor type of cutter—generally used with machines using gripper jaw feed. A, cutting blades; B, actuating piece; C, opening/closing link for upper blade; D, opening/closing link for lower blade; E, cam actuated linkage to time cutting

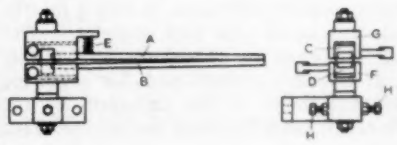


Fig. 10 (left).—Modified scissor type of cutter. AB, cutting blade; CD, pivoted knife holders; E, compression spring; FG, operating arms and carriers; H, pivot height adjusting screws

it is usual to allow about 60° of the machine cycle for closing the blades, making the cut and opening them again, the cut being completed 30° after the blades have started to close. A compression spring is used over the pivot point which, with the set in the blades induces a sideways thrust in the links C D to provide the shearing action.

A further example is shown in Fig 10 in which the knives A B are mounted in pivoted holders C D and are urged into contact by the compression spring E. Each holder is carried in a separate arm F G which can be driven by cam-actuated links. It is usual to be able to adjust the pivot centre of the knives by providing suitable adjusting screws and locknuts H. The arrangement could be modified by designing the arms FG in such a manner that they carry a roller which can be simultaneously actuated by a swinging wedged shaped piece that will open and close the blades.

To be continued.

Graphite Dies

Graphite dies with machined bores of glass like finish are now being manufactured for continuous casting process by Cable and General Instruments Limited. They impart a finish of optimum smoothness to such products as copper alloy and bronze rods, tubes and rectangular sections, and greatly reduce the usual machining process of the end product. These dies also speed the casting process and make it possible to obtain longer footages of rod or tube and a more accurate product. Rods of 1 in. dia up to lengths of 1000 ft have been continuously cast from one die with no appreciable die wear.

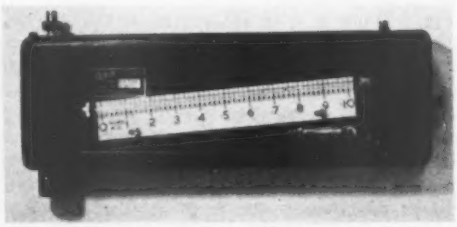
Graphite die partly sectioned to show smooth bore

The quality of the graphite used is of vital importance and many British and Continental graphites were tested before the ideal material was found, and made specially to exacting specifications. It has a high lubrication factor allied to fine grain and allows machining to close tolerances and a glass like finish in the die bore. It is resistant to die burn and gives a good heat transfer from the liquid metal through the graphite to the cooler.

Samples of graphite dies are available to interested firms from Cable & General Instruments Limited, 76 Beckenham High Street, Beckenham, Kent.

15 Watt Soldering Iron

A 15-watt mains-operated soldering iron only 8½ in. long and weighing 3 ozs has been added to the AEI range (AEI Cable Division, 145 Charing Cross Road, London, WC2). It becomes the smallest member of the famous Solon family and, available for operation from 200/220V and 220/240V, retails for 23/4d. in the United Kingdom. The chromium copper bit, retained in its aluminium holder by an aluminium pin the ends of which lie in a groove round the holder, is only ⅛ in. dia, while the stem is only $\frac{5}{16}$ in. dia and completely free from projections. The iron is, therefore, particularly suitable for use in confined spaces and for soldering miniature components liable to be damaged by the application of too much heat. The iron heats to working temperature in 1½ min. It is fitted with a removable hook so that it can be hung in a convenient place when not in use. The two-piece black moulded handle houses all internal connexions between heating element tails and mains flex. A 6 ft length of three-core flex is supplied with each iron. Bits are easily replaced as required and if replacement of the bit holder, heating element or stem becomes necessary, these three components are replaced as one unit.



An example of an Arkon gauge from the new large scale production line

New Inclined Gauges

Walker Crosweller & Co. Limited, of Cheltenham, have re-designed and re-tooled, for large scale production, their range of Arkon inclined gauges, enabling price reductions from 35% to 50% to be made. At the same time the range has been extended from 3-in. water gauge maximum to 4-in. w.g., and other refinements introduced. The Arkon inclined gauge has a magnification of reading of up to ten times so that one tenth of an inch water gauge draught or pressure is represented by one inch of scale length. They also show up differences of draught due to thinning out of fuel bed or clinkering and in general can help to improve boiler house efficiency. The portable type of inclined gauge is frequently used on plant efficiency surveys for spot checking of boiler or kiln draughts or to indicate, for instance, loss of draught through sooting up of smoke pipes and flues. Other uses include differential gas or air pressure measurement and the checking of build up in filters in ventilating systems.

F.H.P. Motors

A new range of fractional horse power motors, designed for industrial and domestic applications, is being produced by English Electric Company Limited, Strand, London WC2. The motors are competitively priced. The latest design techniques—including Class E insulation and double ended ventilation—are used in the new MJ6 range to give minimum weight and frame size for the output. For different applications, a large number of variations on the basic motor are possible by using components from stock. The standard MJ6 range covers sleeve and ball bearing machines with these available mountings: rigid base, resilient base and flange. Lug mounting can also be provided. Both sleeve and ball bearing motors can be drip proof, totally enclosed or totally enclosed fan cooled. There are several core lengths available on one 6 in. dia core, providing outputs from ⅛ to 1 hp. The motors are available with a wide variety of special features and finishes. Motors can be supplied for either three or single phase supply. Three phase motors are suitable for the majority of industrial applications, particularly where there are frequent stops and starts, e.g. on machine tools. Single phase motors are of two types: split phase and capacitor start induction run.

Preliminary Design of Gas Turbine Plant—VII

Blade angles and speeds in the turbine stages

By W. R. THOMSON, B.Sc.Tech.

9. The turbine

9.1. General

This treatment is approximate in the sense that it provides only the main dimensions of the machine, i.e. inside and outside diameters at entry and exit, number of stages, and overall length, all of course pertaining to the bladed portion. The design is limited to the first and last stages, the machine length being obtained by assuming as a mean stage length the average length of the first and last stages. Fig. 15 shows this bladed portion in outline.

9.2. Velocity triangles

Fig. 16 shows the velocity triangles in relation to the blade sections, stator followed by rotor, for the first and second stages. Fig. 17 shows the velocity triangles for one stage as usually superimposed on one another. It will be noted from Fig. 18, which shows a single blade, that due to the increase in blade height across the blade the peripheral velocity of the exit point of a "stream line" will, excepting at the root, be greater than it was at entry. This makes the rotor exit velocity triangle in Fig. 17 greater than the rotor entry triangle, a fact which must be taken into account in the design mathematics. When the reaction is 50%, the two triangles are similar (equal angles) but opposite handed. Reaction may be defined as the static temperature drop in the rotor divided by the total head temperature drop in the stage, which approximates very closely to

$$1-\frac{V_{w_2}^2-V_{w_3}^2}{2(u_1V_{w_2}+u_2V_{w_3})}$$ and in turn this approximates

to $1-\dfrac{V_{w_2}-V_{w_3}}{2u_1}$ or in angles $\dfrac{\tan\alpha_2-\tan\alpha_3}{2u_1/V_{a_1}}$

Fig. 19 shows the relation between gas and blade angles. These angles are named in sect. 2.2.

9.3. Blading

There are no "aerodynamic" shapes for turbine blades as there were for compressor blades. Instead the profiles are formed by a minimum of circular arcs and straight lines. A suggested method for the design of such blading is given in sect. 9.24 with a detailed drawing in Fig. 23. Some twist of the blade accompanies the design condition of the next Section whatever it may be (here it is "free vortex" design).

9.4. Design assumptions

(a) Blade design by the free vortex method, i.e. constant $V_w r$;
(b) constant d_i;
(c) d_i/d_o not less than 0·6 at exit from last stage;
(d) u_i (constant from (b) above) not greater than 600;
(e) 50% reaction at d_m;
(f) M_a into inlet guide vanes (first stage stator) and at exit from first and last stages to be 0·3;
(g) α_3 at blade root in last stage between 0° and 10°;
(h) α_3 at blade root in other stages between −10° and 20°;
(i) pitch/chord ratio $(s/c)_m$ to be between 0·65 snd 0·70 at d_m;
(j) thickness/chord ratio $(t/c)_i$ to be between 0·15 and 0·20 at d_i;
(k) V_a is assumed to remain constant over any annular plane.

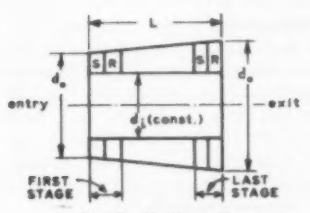
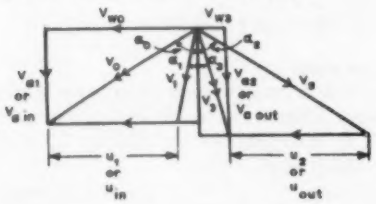
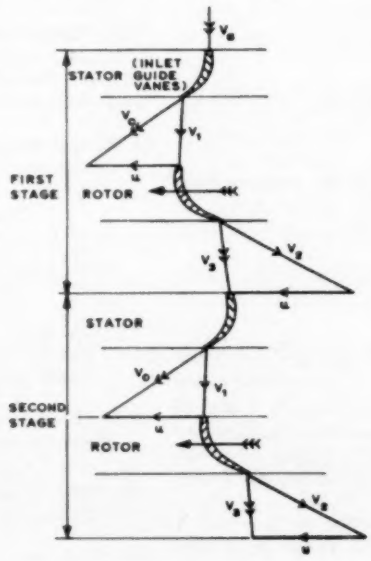


Fig. 15.—Turbine outline

Fig. 16 (right)—Turbine blades with velocity triangles

Fig. 17 (below)—Turbine velocity triangles





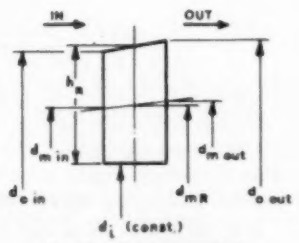


Fig. 18.—Turbine rotor blade

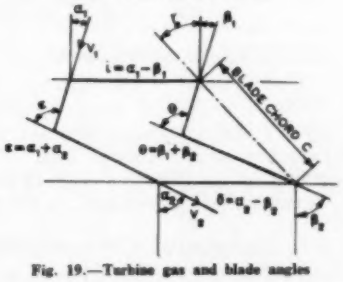


Fig. 19.—Turbine gas and blade angles

A suggested series of values of $(s/c)_m$ and $(t/c)_t$ is tabulated in sect. 9.17.

9.5. Basic equations

The basic equations are

$$gJk\Delta T = u_{in}\,V_{wo} + u_{out}\,V_{w_2}$$
$$= (uV_a)_{in}\tan\alpha_o + (uV_a)_{out}\tan\alpha_2$$

If α_2 is negative, as permitted under design condition (*h*) above for stages other than the last, the + sign in the above equation becomes − *ve*.

$$\text{Tan}\,\alpha_o - \tan\alpha_1 = (u/V_a)_{in}$$
$$\text{Tan}\,\alpha_2 - \tan\alpha_2 = (u/V_a)_{out}$$

both from Fig. 17.

9.6. Simplification of design equations

Simplification results from the assumption (based on the results of applying much more complex methods of design) that the d_m at any rotor blade outlet is 1% greater than that at its inlet. This means that the increase in the height of a blade (see Fig. 18) from its "in" side to its "out" side varies from about 2½% for the last rotor (where $d_t/d_o = 0{\cdot}6$) to about 3½% for the first stage of the 5-stage turbine of the accompanying design study.

Then the work equation of sect. 9.5. when applied at d_m becomes

$$gJk\Delta T = (u_m\,V_a)_{in}\tan\alpha_{om} + (u_m\,V_a)_{out}\tan\alpha_{2m}.$$

As the reaction here is 50%, $\alpha_{om} = \alpha_{2m}$, $\alpha_{1m} = \alpha_{2m}$, and $(u_m/V_a)_{in} = (u_m/V_a)_{out}$; thus

$$\text{Tan}\,\alpha_{om} = (u_m/V_a)_{in} + \tan\alpha_{1m} = (u_m/V_a)_{in} + \tan\alpha_{2m}.$$

Hence $gJk\Delta T = (u_m/V_a)_{in}\{(u_m/V_a)_{in} + \tan\alpha_{2m}\}$
$+ (u_m/V_a)_{out} + \tan\alpha_{2m}$
$= u^2_{m\ in} + \{(u_m\,V_a)_{in} + (u_m\,V_a)_{out}\}\tan\alpha_{2m}$

Since $d_{m\ in} = 0{\cdot}99\,d_{m\ out}$, $u_{m\ in} = 0{\cdot}99\,u_{m\ out}$, and $V_{a\ in} = 0{\cdot}99\,V_{a\ out}$

$$gJk\Delta T = 0{\cdot}98\,u^2_{m\ out} + 1{\cdot}98\,(u_m\,V_a)_{out}\tan\alpha_{2m}.$$

Further with free vortex design for the blading $V_{wo}r$ and $V_{w_2}r$ are constant or $\tan\alpha_{2m} = (d_t/d_o)\tan\alpha_{2t}$
$= (u_t/u_o)\tan\alpha_{2t}$

$$\therefore\ gJk\Delta T = 0{\cdot}98\,u^2_{m\ out} + 1{\cdot}98\,u_t\,V_{a\ out}\tan\alpha_{2t}$$

$$\text{and}\ \tan\alpha_{2t} = \frac{gJk\Delta T - 0{\cdot}98\,u^2_{m\ out}}{1{\cdot}98\,u_t\,V_{a\ out}}$$

$$\text{Also}\ \tan\alpha_{ot} = \frac{gJk\Delta T - u_t\,V_{a\ out}\tan\alpha_{2t}}{u_t\,V_{a\ in}}$$

$$= \frac{gJk\Delta T - u_t\,V_{a\ out}\tan\alpha_{2t}}{0{\cdot}99\,u_t\,V_{a\ out}}$$

Then $\tan\alpha_{1t} = \tan\alpha_{ot} - u_t/V_{a\ in} = \tan\alpha_{ot} - u_t/0{\cdot}99V_{a\ out}$ and $\tan\alpha_{2t} = \tan\alpha_{2t} + u_t/V_{a\ out}$

9.7. Cycle data for turbine

The following data are required for the turbine design from the cycle calculations:

Into turbine:	P_{in}, T_{in}
out of turbine:	P_{out}, T_{out}
overall:	Q, δT, k, δH, γ, $\gamma/\eta_x(\gamma-1)$, q

9.8. Fixing the turbine speed

Using $M_{out} = 0{\cdot}3$ and γ read $(V_a/\sqrt{T})_{out}$ from Table IV. Using T_{out} calculate V_{aout}. Read also $(Q\sqrt{T}/AP)_{out}$ from Table IV. Using T_{out}, P_{out}, and Q calculate A_{out}. Using $d_t/d_o = 0{\cdot}6$, $\frac{1}{4}\pi d_o^2 = A_{out}/0{\cdot}64$ giving $d_{o\ out}$. Then $d_{tout} = 0{\cdot}6\,d_{o\ out}$. Using $u_t = 600$ calculate $N = 229{\cdot}3\,u_t/d_t = 137{,}600\,d_t$. Calculate $\frac{1}{4}\pi d_t^2$.

9.9. Limitation of N by compressor speed

If the turbine must run at a lower speed than that resulting from sect. 9.8, reduce u_t to suit, d_t d_o and A_{out} remaining unchanged.

9.10. Maximum $k\Delta T_2$ for last stage

From design condition (c) $d_o = {}^5/_3\,d_t$ or $d_m = {}^4/_3\,d_t$ and $u_m = {}^4/_3\,u_t$ and for the last stage $\alpha_{2t} = 10°$ at maximum i.e. $\tan\alpha_{2t} = 0{\cdot}1764$ whence

$$\text{Max. } k\Delta T_2 = \frac{0{\cdot}98 \times 16\,u_t^2}{9gJ} + \frac{1{\cdot}98\,u_t\,V_{a\ out} \times 0{\cdot}1764}{gJ}$$
$$= (u_t/161)^2 + (u_t/100)(V_{aout}/100)/12{\cdot}92.$$

9.11. Maximum $k\Delta T_1$ for first stage

Here it is sufficient to assume that the maximum $k\Delta T_1$ for the first (and all other stages except the last) is 10% greater than the maximum $k\Delta T_2$ for the last stage, i.e.

$$\text{Max. } k\Delta T_1 = 1{\cdot}1\ \text{Max. } k\Delta T_2$$

9.12. Number of stages and stage work

Total turbine work is $\delta H = k\delta T$ from the cycle calculations. Find the number of stages, n, so that $(n-1)\,k\Delta T_{1\,max}$ has the smallest value which is greater than $k\delta T - k\Delta T_{2\,max}$. Then find the last stage work

$$k\Delta T_2 = \frac{k\delta T \times k\Delta T_{2\,max}}{k\Delta T_{2\,max} + (n-1)k\Delta T_{1\,max}}\ \text{and the}$$

$$\text{First stage work } k\Delta T_1 = \frac{k\delta T - k\Delta T_2}{n-1}$$

9.13. First stage conditions

9.13.1. Stator inlet

$M_{a\ in} = 0{\cdot}3$. Read $(Q\sqrt{T}/AP)_{in}$ from Table IV. Using T_{in}, P_{in} and Q calculate A_{in}. Then $\frac{1}{4}\pi d_o^2{}_{in} = \frac{1}{4}\pi d_t^2$ (from sect. 9.8) + A_{in}. Hence $d_{o\ in}$.

9.13.2. Rotor outlet

$T_{out} = T_{in} - \Delta T_1$ (from sect. 9.12) and $P_{out} = P_{in}(T_{out}/T_{in})^{\gamma/\eta_x(\gamma-1)}$ $M_a = 0{\cdot}3$ hence $(Q\sqrt{T}/AP)_{out}$ from Table IV. Using (the first stage) T_{out}, P_{out} and Q calculate A_{out}. Then $\frac{1}{4}\pi\,d_o^2{}_{out} = \frac{1}{4}\pi d_t^2 + A_{out}$. Hence $d_{o\,out}$. Read $(V_a/\sqrt{T})_{out}$ from Table IV. Then calculate $V_{a\ out}$ using T_{out}. Note: All further calculations may be carried out in two columns one for each of the two stages.

9.14. Rotor blade mean dimensions

$d_{m\ out} = \frac{1}{2}(d_t + d_{o\ out})$ and $u_{m\ out} = u_t d_{m\ out}/d_t$. See Fig. 17. Rotor blade mean diameter, $d_{mr} = 0{\cdot}995\,d_{m\ out}$ and rotor blade mean height, $h_r = d_{mr} - d_t$.

9.15. Gas angles at roots

From sect. 9.6.

$$\text{Tan}\,\alpha_{2t} = \frac{gJk\Delta T - 0{\cdot}98\,u_{m^2 out}}{1{\cdot}98\,u_t\,V_{a\ out}}$$

$$\text{Tan}\,\alpha_{ot} = \frac{gJk\Delta T - u_t\,V_{a\ out}\tan\alpha_{2t}}{0{\cdot}99\,u_t\,V_{a\ out}}$$

$\text{Tan}\,\alpha_{1t} = \tan\alpha_{ot} - u_t/0{\cdot}99\,V_{a\ out}$
$\text{Tan}\,\alpha_{2t} = \tan\alpha_{2t} + u_t/V_{a\ out}$
Hence α_1 and α_2 (the i may now be omitted).

9.16. Blade angles at roots

At design condition it is usual to assume zero incidence i.e. $i = o$ for all stages. Then $\beta_1 = \alpha_1$. At outlet there will be some deviation, δ, provided for by making $\beta_2 = 10 + 0{\cdot}867\alpha_2$. The camber $\theta = \beta_1 + \beta_2$.

To be continued.

Dimensional Analysis

Dimensional analysis is basically simple and can be a useful guide to engineers in establishing correct units to apply to a basic formula, checking formulae for consistency of units, etc., and simplifying analysis involving a number of independent variables. Principles are discussed on an engineering basis, with typical examples

DIMENSIONAL analysis is a method of dealing with problems rendered complex either by virtue of the number of independent variables involved or because of the complex nature of the relationship involved between the variables. As such it will not, as a general rule, lead to a final solution but rather a general quantitative relationship, and a specific relationship as far as individual units are concerned. Engineers, as a rule, tend to avoid dimensional analysis as being a hypothetical or mathematical subject, when in fact it can be a most useful guide as well as providing a positive method of checking the validity of a working equation derived in arbitrary units and requiring working in specific engineering units.

A dimension, basically, denotes the kind or quality of a physical entity. In geometric and dynamic analysis there are only three fundamental dimensions—Length (L), Mass (M) and Time (T). In some engineering problems Heat (θ) may enter as a fourth dimension. For electrostatic systems the Dielectric Constant (K) may also be concerned; and in electromagnetic systems Permeability (μ). Corresponding derived units, with their respective dimensions, are summarized in Tables I to IV.

The choice of units for any quantity having derived dimensions is largely arbitrary. Thus length may be measured in feet or inches in the fps (English) system; or in centimetres or metres in the metric system. Time units are common to both systems, but again can be measured in seconds, minutes or hours, etc.

Mass units are less readily understood and it is, in fact, the difference between mass as a parameter used in theoretical analysis and weight employed in engineering as a measure of quantity which commonly leads to discrepancies, and is often misunderstood or misapplied.

Mass—basically the quantity of matter in a body—is difficult to define and even more difficult to measure. Weight is easy to measure because it is essentially a force. A weight of one pound, unrestrained, will, for example, move towards the centre of the earth with an acceleration of g ft/sec^2 and from consideration of the laws of motion a weight of W lb must thus correspond to a mass of W/g mass units.

Dimensional analysis depends on the principal that for an equation to be true and have real meaning the fundamental units on either side of the equation must be consistent, i.e. have equal dimensions. This principal can be used as a simple check to avoid inconsistencies arising from the use of units based on both mass and weight as a measure of quantity in the same equation. Thus in the equation

$$\text{Force} = \text{mass} \times \text{acceleration}.$$

If the engineering equation is required to give a solution for imparting an acceleration of y ft/sec^2 to a weight of W lb.

$$\text{Force} = Wy \text{ 'force units'}$$
$$= \text{lb} \times \frac{\text{ft}}{\text{sec}^2}$$
$$= \frac{\text{lb ft}}{\text{sec}^2}$$

The force units are thus seen to be pounds $\times$ ft/sec^2. To render the answer in pounds (force units) it is obvious that it must be divided by a parameter with the units of acceleration (ft/sec^2), i.e. g, when—

$$\text{Force (pounds)} = \frac{\text{Weight (pounds)}}{g} \times y \text{ (ft/sec}^2\text{)}$$

This is now consistent with the basic equation, force = mass $\times$ acceleration, with the established relationship that mass units = weight (pounds)/g.

In any equation of the form

$$A = B \times C \times D$$

dimensional analysis maintains that the units of A must be equal to the product of the units of B, C and D. This is equally applicable to the more general form

$$Q = f(A, B, C, D, \text{etc.})$$

where f is some arbitrary function. The dimensions of the function of the independent variables A, B, C, D, etc. must correspond to those of the dependent variable Q.

This can lead to important conclusions as to which independent variables may be valid for inclusion in an equation, often offering a considerable simplification of analysis. A classic example is establishing the basic

Table I.—DERIVED UNITS (GEOMETRIC AND DYNAMIC)

Unit	Dimensions
Area	L^2
Volume	L^3
Curvature	L^{-1}
Force	$M L T^{-2}$
Work	$M L^2 T^{-2}$
Pressure	$M L^{-2}$
Acceleration	$L T^{-2}$
Angular Acceleration	T^{-2}
Velocity	$L T^{-1}$
Angular Velocity	T^{-1}
Momentum	$M L T^{-1}$
Moment of Momentum	$M L^2 T^{-1}$
Moment of Inertia	$M L^2$
Angular Momentum	$M L^2 T^{-1}$
Torque or Couple	$M L^2 T^{-2}$
Compressibility	$M^{-1} L T^2$
Viscosity	$M L^{-1} T^{-1}$
Density	$M L^{-3}$

Table II.—DERIVED UNITS (HEAT AND THERMODYNAMIC)

Unit	Dimensions
Temperature, thermal units	θ
,, dynamic ,,	$L^2 T^{-2}$
Heat units, thermal	$M \theta$
,, ,, thermometric	$L^2 \theta$
,, ,, dynamic	$M L^2 T^{-2}$
Coeff. thermal expansion	θ^{-1}
Conductivity, thermal units	$M L^{-1} T^{-1}$
,, thermometric units	$L^2 T^{-1}$
,, dynamic units	$M L T^{-2} \theta^{-1}$
Latent heat, thermal units	θ
,, ,, dynamic units	$L^2 T^{-2}$
Joule's equivalent of heat	$L^2 T^{-2} \theta$
Entropy, thermal units	M
,, dynamic units	$M L^2 T^{-2} \theta^{-1}$

relationship between the time of swing of a pendulum and the various independent variables which may affect the time. In the general form, the equation may be written

$$t = f(m,l,g,\alpha)$$

where t = time of swing
m = mass of pendulum
l = length of pendulum
g = acceleration due to gravity
α = angle of displacement or amplitude of oscillation.

Fundamental dimensions are

$$T = f(M,L,LT^{-2})$$

The angle α has no dimensions since it is essentially a ratio (i.e. arc divided by radius).

A study of these dimensions shows that the fundamental unit M occurs only once, on the right hand side. There is no way of combining it with any of the other independent variables so that it disappears from the right hand side of the equation. The only conclusion, therefore, is that time t is *not* dependent on mass. Dimensional analysis, therefore, predicts that the mass of the pendulum does not affect the time of swing, which is verified by experiment.

Further consideration of dimensions then leads to the two following assumptions—

(i) To derive the dimension T from the right hand side of the equation, the independent variable g must be rendered in the form $g^{-1/2}$

(ii) To cancel the L dimension of $g^{-1/2}$, the L dimension for the length of the pendulum must be rendered in the form $l^{1/2}$

Thus dimensional analysis predicts

$$t = l^{1/2} g^{-1/2} \phi(\alpha)$$

where $\phi(\alpha)$ is some arbitrary function of the angle of displacement which cannot be determined by dimensional analysis.

This, of course, is consistent with the established formula for the time of swing of a pendulum

$$t = 2\pi\alpha \sqrt{\frac{l}{g}}$$ (for small values of α; $\phi(\alpha)$ being modified for larger amplitudes).

As an example of how elementary dimensional analysis may be used to establish the correct units for one of the independent variables in an engineering equation, consider the formula for the pressure drop in a fluid stream across an orifice

$$\Delta P = \frac{KQ^2\rho}{d^4}$$

where ΔP = pressure drop—dimensions ML^{-2}
K = orifice coefficient—dimensionless
Q = flow rate—dimensions L^3T^{-1}
ρ = density—units not clear
d = orifice diameter—dimension L

We have, on the left hand side, dimensions = ML^{-2}

on the right hand side, dimensions = $\dfrac{(L^3T^{-1})^2 \times \overline{D}}{L^4}$

where $\overline{D}$ represents the (unknown) dimensions for density.

For the right hand side to equal the left hand side, it follows that the units of density required are MT^2L^{-4} or mass per unit volume divided by the acceleration due to gravity (i.e. density/g).

Various other important relationships apply in dimensional analysis. The 'pi' theorem, for example, states that the relationship between m different variables can be rendered in terms of $m-n$ groups, each of which is dimensionless in terms of the n fundamental dimensions concerned. Thus, for example, with five independent variables involving three fundamental dimensions, $m = 5$ and $n = 3$. Thus these variables can be reduced to $5-3 = 2$ groups which are dimensionless.

Again this can be illustrated by the pressure drop equation considered above, rendering the term g correctly in the denominator.

$$\Delta P = \frac{KQ^2\rho}{gd^5}$$

rewriting $K = \dfrac{\Delta P g d^4}{Q^2\rho}$

The left hand side of the equation is now dimensionless. Consistent with this the right hand side can now be rearranged in two groups, each of which again is dimensionless—

$$\left(\frac{\Delta P}{\rho d}\right) \left(\frac{gd^5}{Q^2}\right)$$

Checking the dimensions of the first group

$$\frac{ML^{-2}}{ML^{-3} \times L} = O$$

Checking the dimensions of the second group

$$\frac{LT^{-2} \times L^5}{(L^3T^{-1})^2} = O$$

This theorem may thus be particularly useful to arrive at dimensionless parameters which may be derived from a given equation, relationship or analysis. It should be noted, however, that such dimensionless groups become specific to particular derived units once any one fundamental is rendered in specific units.

Table III.—DERIVED UNITS (ELECTROSTATIC)

Unit	Dimensions
Quantity (of electricity)	$M^{1/2} L^{3/2} T^{-1} K^{1/2}$
Potential	$M^{1/2} L^{1/2} T^{-1} K^{-1/2}$
Electromotive force	$M^{1/2} L^{1/2} T^{-1} K^{-1/2}$
Current	$M^{1/2} L^{3/2} T^{-2} K^{1/2}$
Current density	$M^{1/2} L^{-1/2} T^{-2} K^{1/2}$
Resistance	$L^{-1} T K$
Resistivity	$T K^{-1}$
Dielectric constant	K
Conductivity	$T^{-1} K$
Conductance	$L T^{-1} K$
Electrostatic capacity	$L K$
Quantity of magnetism	$M^{1/2} L^{1/2} K^{-1/2}$
Magnetic Flux	$M^{1/2} L^{1/2} K^{-1/2}$
Magnetising force	$M^{1/2} L^{1/2} T^{-2} K^{1/2}$
Magnetic moment	$M^{1/2} L^{5/2} K^{-1/2}$

Table IV.—DERIVED UNITS (ELECTROMAGNETIC)

Unit	Dimensions
Quantity	$M^{1/2} L^{1/2} \mu^{-1/2}$
Potential	$M^{1/2} L^{3/2} T^{-2} \mu^{1/2}$
Electromotive force	$M^{1/2} L^{3/2} T^{-2} \mu^{1/2}$
Current	$M^{1/2} L^{1/2} T^{-1} \mu^{-1/2}$
Resistance	$L T^{-1} \mu$
Dielectric constant	$L^{-2} T^2 \mu^{-1}$
Conductivity	$L^{-2} T \mu^{-1}$
Capacity	$L^{-1} T^2 \mu^{-1}$
Conductance	$L^{-1} T \mu^{-1}$
Resistivity	$L^2 T^{-1} \mu$
Current density	$M^{1/2} L^{-3/2} T^{-1} \mu^{-1/2}$
Quantity of magnetism	$M^{1/2} L^{3/2} T^{-1} \mu^{1/2}$
Magnetic Flux	$M^{1/2} L^{3/2} T^{-1} \mu^{1/2}$
Magnetising Force	$M^{1/2} L^{-1/2} T^{-1} \mu^{-1/2}$
Magnetic moment	$M^{1/2} L^{5/2} T^{-1} \mu^{1/2}$

Considerations in the Design of a Copper Scrap Refining Furnace—II

Introducing a new technique involving metallurgy and heat transfer with steam raising

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Heat transfer in furnace from flame

THRING (References 7 and 8), in his various papers on this problem, has stated the assumptions made and the method used for a practical solution of this problem. These are as follows:

(1) Each flame is assumed to have the same dimensions as the port mouth, and to proceed along the furnace axis without change of cross-sectional area.

(2) Combustion is assumed to follow a path whereby 30% of the fuel is burnt inside the inlet port and all the fuel is consumed by the time the exit port is reached.

(3) The producer gas when used as a fuel is taken to have a calorific value of 1550 Chu/lb requiring 1·85 lb air per 1 lb fuel for stiochrometric combustion and it is burnt with 5% excess air.

The temperature of the mixture of unburnt gas, air and combustion products is assumed to be a function only of distance across the furnace, and to be constant over any cross-section.

Any net lateral exchange of heat between flames is neglected so that in the case of multiple burners each flame is taken to be independent of the rest.

The heat loss to the outlet end of the furnace or to the discharge port in the side is assumed to be equivalent to that transferred from an enclosure at 1450° C to one at 1200° C.

Emissivity measurements give 0·8 for the head of the flame and 0·2 for the tail, and it can be assumed that the emissivity decreases unevenly down the furnace.

The emissivity of the roof is assumed to be 0·7 and the molten copper 0·7, with a surface temperature of 1450° C. Forming the heat balance for the roof, which is receiving radiation from the flame and from the molten copper, whilst itself radiating, the net heat transfer by radiation to an area δ_s on the inside of the roof from any zone is given by:

$$NR = \epsilon'\delta S\left[2\int_0^{\alpha_1}\int_{\beta_2}^{\beta_2}\frac{\sigma T_f^4}{\pi}(1-e^{-Kd\sec\alpha\sec\beta})\cos\alpha\cos^2\beta\,d\alpha\,d\beta + 2\int_0^{\alpha_1}\int_{\beta_1}^{\beta_2}\frac{\sigma T_c^4}{\pi}(e^{-Kd\sec\alpha\sec\beta})\cos\alpha\cos^2\beta\,d\alpha\,d\beta + \int_{\alpha_1}^{\alpha_2}\int_{\beta_1}^{\beta_2}\frac{\sigma T_c^4}{\pi}\cos\alpha\cos^2\beta^1\,d\alpha\,d\beta^1 - 2\frac{\sigma T_R^4}{\pi}\left\{\int_0^{\alpha_1}\int_{\beta_1}^{\beta_2}\cos\alpha\cos^2\beta\,d\alpha\,d\beta + \int_{\alpha_1}^{\alpha_2}\int_{\beta^1_1}^{\beta^1_2}\cos\alpha\cos^2\beta^1\,d\alpha\,d\beta^1\right\}\right]$$

$$= \epsilon'\delta S\,[\phi_1+\phi_2+\phi_3-\phi_4]$$

ϵ' = emissivity of roof

K = flame resistivity

α = flame thickness feet

$T_f\,T_{Cu}\,T_R$ = mean absolute temperature flame copper and roof

$T_f = \dfrac{(T_a+T_b)}{2}$ T_a and T_b being temperature at beginning and end

σ = Stefan—Boltzmann constant

α_1 = angle subtended by half flame width

β_1 = angle defining zone length along flame or in the zone width

β = angle defining zone length along the flame or in the flame width.

A solution can be obtained by expanding this equation into exponential absorption terms and integrating and then summarising the first few terms of the resulting rapidly convergent series which gives T_R in terms of T_f, since the effective roof loss NR is known.

Using a linear approximation to the curve for black body radiation against temperature the equation of line is:

$$\sigma T^4 = 264\ \theta - 297{,}000\ CHU/\text{ft}^2\text{hr}.$$

where θ is temperature in degrees C.

The roof will reflect energy incidental from the flame and copper metal, and will also radiate energy and the total energy so transferred from an area δS of the roof is:

$$R = \delta S\,(1-\epsilon')\,\Sigma[\phi_1+\phi_2+\phi_3] + \epsilon'\delta S\sigma\,T_R^4$$

If the roof behaves as a perfect diffuse reflector, this corresponds to radiation of a specific intensity R/π per unit solid angle per unit area directed towards the metal surface.

Then the energy absorbed by the metal copper is given by:

$$Cu = \epsilon''\left[\left\{\Sigma\left(\frac{R}{\sigma T_g^4}-\delta S\right)(\phi_2+\phi_3)\right\} + \epsilon A\sigma T_f^4\right]$$

where ϵ'' is the emissivity of the copper surface

ϵ the hemispherical emissivity of the flame

A the area of melt under the flame.

The total heat transferred to the copper can be computed in this way and amounts to 35% of the whole, including in this figure heat losses from the sides and bottom of the furnace lining.

Stage 2—Furnace design

Having obtained the total weight of charge to the furnace by the methods of Stage 1, and using an average bulk density, this charge is then considered to fill one-

third of the cross-sectional area of the furnace over an assumed length of 15 ft. This gives a furnace inside diameter of 3 ft 6 in. and with a furnace lining 15 in. thick, would give an overall furnace diameter of 6 ft.

In order to determine the time to heat up the charge to 2000° F, this is assumed to line the walls of the furnace as a slab of 6 in. thickness, and to be heated from the centre of the furnace by hot gas at a temperature of 2500° F.

Given the following mean values for the charge:

k = thermal conductivity
= 0·6 Btu/(hr) (ft²) (°F/ft)
ρ = bulk density
= 350 lb/ft³
c = specific heat
= 0·26 Btu/(lb) (°F)
h = total heat transfer coefficient
= sum of radiation and convection coefficients
= 6 Btu/(hr) (ft²) (°F)
α = thermal diffusivity
= $k/c\rho$
l = thickness of slab in direction of heat travel
= 0·5 ft
x = surface distance for heat travel
$Y = (T_s - t)/(T_s - t_o)$

where T_s = temperature of combustion gas
t = face surface temperature
t_o = back surface temperature
θ = time in hours for heating up the slab to the face temperature.

Gurney and Lurie noted that the relationships for heating various shapes could be represented by the four dimensionless groups $4 \times \theta/l^2$, $(T_s - t)/(T_s - t_o)$, $2k/hl$ and $2x/l$.

With these dimensionless parameters they made plots for the finite wall (slab), cylinder of infinite length, sphere and semi-infinite solid, and part of that for the slab covering $2k/hl = 0{\cdot}5$ and $2x/l = 0 \rightarrow 1$, is reproduced in Fig. 3.

Using the Gurney-Lurie chart

$\alpha = k/c = 0{\cdot}6/(0{\cdot}26 \times 350) = 0{\cdot}0665$

$Y = (T_s - t)/(T_s - t_o) = (2500 - 2000)/(2500 - 70)$
$= 0{\cdot}206$

$2k/hl = (2 \times 0{\cdot}6)/(6 \times 0{\cdot}5) = 0{\cdot}4$ . . . . . (1)

$2x/l = 1$ . . . . . (2)

Assuming the chart to be for $2k/hl = 0{\cdot}4$

$4\alpha\theta/l^2 = 0{\cdot}8$ or $4 \times 0{\cdot}0665 \times \theta/(0{\cdot}5)^2 = 0{\cdot}8$

whence $= (0{\cdot}8 \times (0{\cdot}5)^2)/(4 \times 0{\cdot}0665) \doteq 0{\cdot}75$ hr.

The chart is, in fact, for $2k/hl = 0{\cdot}5$ and the value of θ is therefore slightly on the high side.

Checking on the combustion space available from Section 3, the heat to be applied by the combustion of the fuel oil amounts to 5,300,000 Btu/hr.

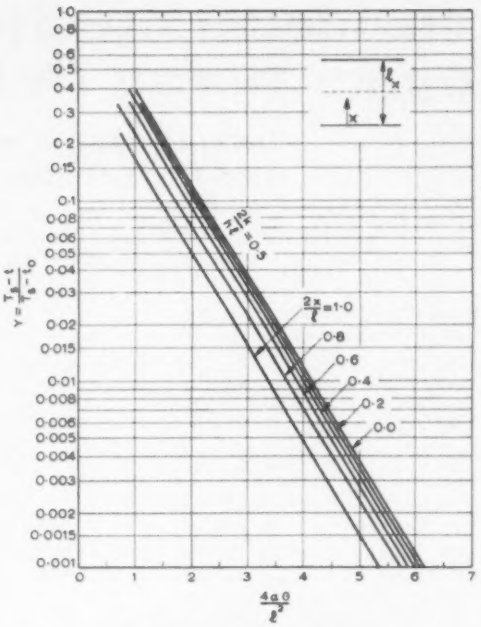
Since the total combustion space is only two-thirds of the furnace cross-sectional area, then the whole space available for combustion is:

$$\tfrac{1}{4}\pi \times (3\tfrac{1}{2})^2 \times 12\tfrac{1}{2} \times \tfrac{2}{3}$$

The supply of 1,000,000 Btu per min to this space is equivalent to:

$$\frac{5{\cdot}3 \times 10^6}{3600} \times \frac{3}{\pi \times 3 \times 12\tfrac{1}{2} \times 2} \doteq 2{\cdot}0 \text{ Btu/ft}^3\text{/sec}$$

According to References 4 and 5 this is a good average value requiring good atomization and high temperature,



Gurney-Lurie chart for slab heating

but this is considered to be easily achievable under these conditions.

Charge and operation sheet for production of 5 short tons of tough pitch copper

Scrap charge	= 10,000 lb	= 10,000
Silica sand	= 5 × 880 lb	= 4,400
Limestone	= 5 × 640 lb	= 3,200
	Total	17,600 lb

Operation cycle

Time to bring charge up to 2000° F approx.	= 1 hr
Melting and fluxing time	= 5 ,,
1st oxidation blow for clean slag	= 1 ,,
2nd oxidation blow for rich slag	= 1 ,,
Deoxidation and refining	= ½ ,,
Slagging and ingot casting time	= 1 ,,
Charging scrap, flux, charcoal	= ½ ,,
	10 hr

Average rate of production per furnace = 10 cwt per hr.

To be continued.

Nylon Core Belt

An improved Nylon core belt based on the already established "Nycor" has been launched by Graton & Knight, Warwick Road, Boreham Wood, Herts. The new belts have been successfully installed on drives where the belt traverses the complete drive more than 50 times a second, where there have been pulley ratios of 50:1 and on extremely short centres with pulley faces almost in contact. The nylon is the full width of the belt and without longitudinal joints and permits use of a thinner core to transmit the same horsepower, with a consequent increase in flexibility which widens the range of applications, smaller pulley diameters being used to advantage.

Temperatures and Soft Soldering

Although a basic technique where the manual skill involved can readily be mastered with practice, efficient soldering demands particular attention to bit temperature. Temperature requirements are discussed together with the effect of using different solder alloys and general recommendations are given on the selection of suitable electric instruments

COMMON practice in many factories is to use a low voltage soldering iron connected to a low voltage supply (usually 50V) from a transformer. This method has a number of advantages. Low voltage iron elements are generally more robust than their high voltage counterparts. With a transformer supply variations in mains voltage can usually be adjusted, if necessary, to maintain an adequate performance from the irons in use. Also no earth wires are needed on the iron leads so that the flex can, if necessary, be somewhat lighter and more flexible.

Apart from cleanliness, temperature is probably the most important single factor in successful soldering, whether on a 'one off' basis or on a production run. The basic difference between the two types of job requirements, as affecting choice of instrument, is that in the latter case the size of the iron should be sufficient to retain enough residual heat for continouus or semi-continuous work. There are no hard and fast rules on this point as the size and weight of the instrument must be matched to the convenience of handling on the job and the heat lost can be a variable factor with different operators—e.g. the time an individual operator takes to complete a successful joint. Lack of temperature can be due to the use of too small an instrument, poor technique or low voltage. Whatever the cause it will be costly on the production side, and frustrating from the operator's point of view.

Choice of solder also has a bearing on the temperature requirements of the iron. Solder, basically, is a tin/lead alloy where the proportion of tin may vary from 60% to 20%. The higher the tin content the lower the melting point of the solder. Equally, of course, the lower the the maximum service temperature the soldered joint will withstand without softening again.

A simple alloy will have only one sharp melting point given by the eutectic composition. In the case of tin-lead alloy the eutectic composition is 63/37 tin/lead, which melts at 183° C. All other alloys with a different composition will commence to melt at this temperature but will not be fully molten until a higher temperature is reached. This final temperature is generally defined as the liquidus, i.e. the lowest temperature at which the alloy becomes fully liquid. Of the standard commercial solders, 60/40 alloy has a liquidus temperature of 189° C (closely approximating to the true eutectic alloy), whilst at the other end of the range, 20/80 alloy which is employed for jobs required to withstand a higher service temperature (e.g. on motors and dynamos), the liquidus temperature is 275° C, nearly 100° C higher. Other typical liquidus temperatures are summarized in Table 1.

Outside this range the high temperature (silver) solders have to be employed where higher service temperatures are met with. At the other end of the scale, special low melting point solders may be chosen where work surfaces are particularly heat-sensitive or soldering must be done at the lowest possible temperature. These are based on the low melting point alloys—e.g. tin/lead plus cadmium for moderately low temperatures (e.g. melting at 145° C) and giving an excellent solder for low temperature work. Tin/cadmium is also used for a lead-free solder, although this alloy has a melting point of 177° C in eutectic composition. Bismuth alloys tend to have very low melting points in eutectic composition but are not widely used as practical low temperature solders, mainly because of the fact that they do not tin readily. Many also expand on solidification which could be inconvenient in certain designs. Wood's metal (a eutectic alloy of bismuth-tin-lead-cadmium) is, however, a useful alloy for very low temperature soldering which is good with all types of flux and melts at only 70° C.

For satisfactory soldering performance a bit temperature of at least 40° C above the liquidus of the solder is necessary. Thus the bit temperature—as affecting the choice and size of iron, etc.—is dependent on the type of solder used. The majority of work is carried out with a 60/40 alloy when a bit temperature of at least 229° C is called for. Other alloys ranging between 50/50 and 40/60 tin/lead are, however, quite widely used throughout the radio and electrical industry. Thus an iron which realised a bit temperature of say 250° C, might be perfectly satisfactory with 60/40 alloy but give increasingly inferior work with any of the other solders with higher lead content.

One of the chief reasons for using a solder with a higher lead content is lower cost, the price of tin being some five to seven times that of lead. Also where there may be restrictions on the use of tin as a strategic material, the 40/60 solder alloy may be more widely used (as it is in the United States radio and electronic industry, for example). The actual saving in cost between 60/40 and 40/60 solder is of the order of 15 to 20% which could be significant where large quantities are consumed. It will be necessary when choosing a lower tin content solder to ensure that sufficient bit temperature is available, and also to bear in mind that joints soldered in 40/60 alloy will take longer to cool and solidify.

A useful application of different melting points is where two separate joints may have to be completed by

Table I.—TYPICAL RANGE OF SOFT SOLDERS

Alloy Tin/Lead	Liquidus °C	Bit Temp. Required °C
60/40	189	229
50/50	214	254
45/55	225	265
40/60	232	272
30/70	255	295
20/80	275	315

soldering to a common base or mount (e.g. to opposite end of a tag). The use of a high melting point solder on the first joint (e.g. 20/80 alloy or a silver/tin/lead solder melting at 296° C) means that the second joint can be completed with 60/40 alloy without danger of softening or disturbing the first joint. Alternatively to the two alloys mentioned, pure tin is sometimes used as the solder for the first joint.

The majority of factories use electrically heated irons, although some use irons heated in electric or gas muffles and others gas heated irons. Independently heated irons may be more common in general engineering production but again the proportion of electric irons is high. General comments on bit and iron performance can, therefore, be confined to electrically heated irons containing an integral element. They generally have an advantage in weight, selection and control of bit temperature, ease of replacing bits, etc., although incorporating an 'expendable' component in the element (which will need periodic replacement with continuous use, and usually, but not necessarily, the bit).

Electric iron performance is not always clear from manufacturers' ratings, which may be purely nominal without reference to bit temperature; or subject to considerable variation in actual bit temperature over a number of specimens measured against quoted bit temperature. In the former case differences in bit temperature of as much as 100° C have been observed with irons of different manufacture but of similar (bit) size and wattage rating.

The mains iron is usually produced with a range of elements suited to different voltages. In general the iron is specified for a voltage range—e.g. 220/230, 230/240, etc., In such cases the element is almost invariably designed for the mean voltage—i.e. 225 volts and 235 volts, respectively, in the above cases. Whilst the mean voltage should give the correct (design) bit voltage the loss of temperature on operating on the lower voltage figure is not usually significant unless the mains voltage is down. Thus under conditions where it is known that the mains voltage is consistently down, a 210/220V iron could be chosen for a 230V (nominal) supply; a 220/230V iron for a 240V supply, and so on. Over-running the iron—e.g. using a 220/230V iron on a (full) 240V supply can also be employed to boost bit temperature for handling the higher lead content solders comfortably, or even the softer silver solders. About the only disadvantage in over-running is a reduction in element life. This is certainly to be preferred to working with too cold an iron and is better economy in giving faster production and reducing the chance of faulty joints.

Table II lists typical performance figures quoted for a range of proprietary electric irons intended primarily for working with 60/40 solder. The necessary bit temperature is reached in a matter of 1-4 min, depending on the size of the iron, whilst the saturation temperature realized is sufficient for soft silver soldering. Both temperature figures must be regarded as typical rather than specific for there will be some variation according to type. All show, however, an ample reserve of performance to cope with virtually any soft soldering job.

TABLE II.—TYPICAL PERFORMANCE OF A RANGE OF PROPRIETARY ELECTRIC IRONS (Mains Type)*

Size	Weight		Time for Bit to reach 250°C	Time for Bit to reach Saturation Temp. ▽
	Bare Iron	With Flex		
	oz	oz	min	min
10 watt	¼	½	1	3½
20 ,,	1½	3	1¼	5
25 ,,	2	3½	1½	6
30 ,,	3	4½	2	6½
35 ,,	3½	5	2½	7
55 ,,	7	10	4	12

*Light Soldering Developments Limited. ▽ Approx. 375°C

A bit temperature of 250° C represents a satisfactory operating point for soldering with 60/40 alloy, and hence time to heat up to this figure has a certain significance where the iron is used for occasional work. The difference between the saturation temperature achieved and the required minimum bit temperature (e.g. 40° C above the liquidus of the solder) offers a certain guide as to the reserve of heat the iron is likely to maintain, and the rapidity with which a joint may be completed. The mass of the bit will largely determine the heat reserve and a tiny bit even at high temperature will quickly lose its its heat by conduction when applied to a large mass of metal, or metal components with good heat conductivity.

The performance of the iron as a production tool is best evaluated by practical tests, confirming such factors as bit temperature maintained during a normal cycle of operation, suitability of the size of iron to job requirements, etc. Irons should not be larger than necessary for extra weight means additional fatigue which can lead to a deterioration in workmanship. Equally, an iron should not radiate excessive heat to the extent that it can cause distress or discomfort to the operator.

Whilst the type of bit is always related to the job requirement it is an advantage to select a standard bit form of regular shape rather than a special shape. For light work, fixed copper bits are probably the most efficient, although erosion of the bit is inevitable. Copper bit life can be materially improved by using the most suitable form of flux or fluxed solder. Replaceable copper bit irons are, however, more usual on factory production lines. In particular instances a special steel bit (e.g. a 'Permabit') may offer a distinct advantage, this type, of bit lasting indefinitely and not requiring the usual reshaping at intervals. Such a bit does not, however, give the same amount of heat as a copper bit of the same size and where space limits the size of bit which can be used comfortably or safely the latter is usually better. These special permanent bits, incidentally, are usually most efficient in the smaller sizes.

Although it may not appear to be the case at first sight, more harm can be done to heat-sensitive components by using too low a bit temperature than too high a temperature. This is because in the former case it is necessary to keep the iron in contact with the component for a longer period (and the operator tends to hold it in place much longer than necessary to 'make sure'). More heat is thus conducted into the component than would be the case of a quickly-completed soldered joint made with a hot iron. This applies in particular to the soldering up of electrical assemblies where transistors, resistors, capacitors, etc., must all be regarded as heat-sensitive (particularly the first). The use of a heat shunt to collect surplus heat when soldering up transistor leads is not normally necessary with most types of present-day transistors, provided the bit temperature is not excessively high and the bit is not held in contact with the lead for more than a few seconds. Individual manufacturers, however, usually have specific recommendations on this point and should be consulted where necessary.

Research and Power Reactors in Canada—V

—*a review of progress*

By J. R. FINNIECOME, M.Eng., M.I.C.E., M.I.Mech.E., F.Inst.F., Consulting Engineer

19. Relative costs of heavy water

One set of comparative costs of three processes, (a) distillation of hydrogen, (b) catalytic exchange, (c) distillation of water, is given in Table XI.

The most attractive of the three processes is undoubtedly the distillation of hydrogen. Production cost, excluding capital charges, at the Savannah River plant is \$13·5 per lb equal to \$30,240 per ton (£4·84 per lb corresponding to £10,842 per ton). The present day selling price of heavy water produced in the United States is \$28 per lb (£10 per lb) equivalent to \$62,720 (£22,400) per ton.

20. Heavy water production at Savannah River

As this plant is the largest producer of heavy water in the world and noted for a much lower cost it is instructive to examine the summary of essential particulars contained in Table XII. Special attention and much thought had been given to the selection of the most economic process. A combination of three different methods is operated in series. The dual temperature exchange between hydrogen sulphide and natural water is used for the first concentration of D_2O, followed by vacuum distillation and then electrolysis for obtaining the final concentration of 99·75% (item 7). The plant was constructed during 1951 and 1952 at a capital cost of \$164 million (£58·5 million). The maximum rate per annum is 1,000,000 lb equal to 446·5 ton per yr. Therefore the capital cost was \$164 (£58·5) per lb. Production cost is \$13·5 (£4·84) per lb and the selling price since 1956 has been \$28 (£10). The heavy water is supplied in non-returnable stainless steel drums in two sizes containing 125 and 300 lb, costing \$43 (£15. 7s.) and \$100 (£35. 14s.) each.

The electrolytic plant which increases the concentration from 90% to 99·75% contains 150 cells, each consisting of a carbon cylinder about 12 in. dia that functions as a cathode and a smaller concentric nickel insert which acts as the anode. This cylindrical insert enables the gas to mix freely within the cell. The cells are cooled by a water jacket at about 25°C (77°F) and each is capable of passing a current of 1000 amp with a voltage drop of 3 V. The cells are operated in series electrically and the direct current is supplied by a rectifier, designed for 1·000 amp at a maximum of 525 volt. The cost of the electrolytic plant was about \$1·5 million (£535,000). The United States Atomic Energy Commission has since built a large installation at Dana, Indiana, which began production in 1957.

Table XI.—COST OF PRODUCING HEAVY WATER

Process	Cost (including fixed charges) per ton \$	Cost (including fixed charges) per ton £	Cost (excluding fixed charges) per ton \$	Cost (excluding fixed charges) per ton £
(a) Distillation of hydrogen	132 000	47 200	46 000	16 500
(b) Catalytic exchange	145 000	52 000	55 000	19 750
(c) Distillation of water	570 000	204,000	350 000	125 500

Table XII.—HEAVY WATER PRODUCTION PLANT AT SAVANNAH RIVER

1. Owner	U.S. Atomic Energy Commission
2. Construction date	1951/1952
3. Total capital cost	\$164 000 000 (£58 500 000)
4. Maximum annual production rate of heavy water	1 000 000 lb per yr (446,5 ton per yr)
5. Total capital cost of plant per lb. per yr	\$164 = £58·5
6. Total capital cost of plant per ton per yr	\$367 300 (£131 500)
7. Method of production: heavy water is extracted from natural water using a combination of three processes:	
(a) Dual temperature exchange between hydrogen sulphide and natural water to production 15% D_2O concentration	
(b) Vacuum distillation to concentration of about 90% D_2O	
(c) Electrolysis to concentration of 99·75% D_2O	
8. Production cost analysis excluding capital charges per lb of heavy water	\$
(a) Feedwater	0·40
(b) Hydrogen sulphide	0·44
(c) Wages and salary (direct)	2·62
(d) Electric power	1·33
(e) Steam	4·40
(f) Cooling water	0·12
(g) Repairs material	0·49
(h) Miscellaneous supplies and expenses	0·21
(i) Administrative and general expenses (overhead)	3·49
Total production cost	\$13·50 (£4·84) per lb
9. Selling price per lb of heavy water	\$28·0 (£10) per lb

21. Principal plants producing heavy water

Achievements in the commercial production of heavy water are best demonstrated by the number of plants installed in Norway, Canada and the United States, the essential facts concerning which are presented in Table

Table XIII.—PLANTS PRODUCING HEAVY WATER IN NORWAY, CANADA AND UNITED STATES

1 Item	2 Country	3 Owner	4 Location	5 Plant in Production	6 Output per month in tons	7 Process
1	Norway	Norsk Hydro Co.	Rjuken	1934		Electrolysis of water
2	Canada	Consolidated Mining and Smelting Co. of Canada Ltd (COMINCO)	Trail (British Columbia)	1943	0·55	Catalytic exchange between hydrogen and water vapour combined with electrolysis
3	United States	U.S. Ordnance Factories				
		(a) Morgantown	Morgantown (Virginia)	1944	0·28	Distillation of water
		(b) Alabama	Childersburg (Alabama)	1944	0·26	
		(c) Wabash	Wabash, near Newport (Indiana)	1944	0·66	
4	United States	U.S. Atomic Energy Commission	Savannah River (South Carolina)	1952	37·2	Dual temperature—hydrogen sulphide exchange combined with vacuum distillation and electrolysis (see Table XII)
			Dana (Indiana)	1957		

XIII. The plants in items 2 and 3 were most urgently planned to produce heavy water in connection with the atom bomb. Since 1945 they have been regarded as obsolete for the entire supply of heavy water is produced at Savannah River and at Dana.

Similar information on the two pilot plants in France and one in Switzerland, and a commercial project in India on the Sutlej River, near Nangal Dam of the Bhakra-Nangal hydro-electric scheme, in Punjab, is contained in Table XIV. The electric power required by this plant is 112 MW, to be supplied from the 450 MW Bhakra power station consisting of five sets of 90 MW water wheel generators driven by Francis turbines. The first set was in commission at the beginning of 1960. The installation designed for the electrolysis of water has been under construction since 1958. Its electric power requirements are about 25% higher than a similar plant at Rjuken, Norway, which uses the same process and was the first in the world to produce heavy water. It has been in operation since 1934 (Table XIII, item 1). France's first pilot plant for the production of heavy water uses the hydrogen sulphide-water exchange process, therefore it has been built at Lacq, in the Basses-Pyrénées, where the national gas deposits, worked by Société Nationale des Petroles d'Aquitaine, contains a heavy portion of hydrogen sulphide (15% in volume) which after purification may be used as gas supplement for this pilot plant.

An experimental and an industrial pilot plant have been built in France using the liquid hydrogen process. This method was the subject of an intensive study in 1953 by Air Liquide (AL) with the co-operation of the Office National Industriel de l'Azote (ONIA) and the Compagnie Française de l'Eau. The plants were built by AL on the premises of ONIA at Toulouse and are operated by CFEL. The pilot plant was started up in 1957 and the estimated annual output of heavy water is 2 tonne.

A larger plant to produce 40 tonne per yr of heavy water has been planned for Toulouse applying the same process. It has been estimated that the capital cost of such a liquid hydrogen plant for producing heavy water would be about $425,000 (£152,000) per tonne per yr. The power consumption, which was difficult to assess accurately, is expected to be 4 to 6 kWh per gram.

In the prototype heavy water production plant at Domat/Ems in Switzerland, the process used is a combination of:

(a) electrolysis of natural water for the first step which increases the concentration of deuterium from 0·0154% in natural water to about 0·10%.
(b) compressing and then cooling the hydrogen-deuterium mixture to the liquefying temperature of −250°C (22°K).
(c) first vacuum distillation (this brings the concentration up to about 40%).
(d) combustion of HD by means of a burner.
(e) second vacuum distillation (final concentration of D_2O, 99·8%).

The consumption of electric energy for the Domat/Ems plant is stated about 2 to 3 kW h per gram D_2O, whilst for the entirely electrolytic process it would be 120 to 150 kW per gram D_2O which is 60 to 50 times greater. A three-stage reciprocating compressor compresses the hydrogen gas from 1·5 ata to 14 ata. It is then cooled to the liquefying temperature of 22°K by means of heat exchangers and three expansion turbines. It is the first time that the latter have been applied for the liquefaction of hydrogen. The complete plant was designed and manufactured by Sulzer Brothers, Winterthur, in collaboration with Professor K. Clusius, University of Zürich, Dr P. Grassmann, Federal Technical University, Zürich, and Dr W. Kuhn, Professor at the University of Basle.

Table XIV.—PLANTS PRODUCING HEAVY WATER IN FRANCE, GERMANY AND INDIA

1	2	3	4	5	6	7
Item	Country	Owner	Location	Plant in operation	Output per year	Process
1	France	Société National des Petroles d'Aquitaine	Lacq (Basses-Pyrénées)	1955		Hydrogen sulphide-water exchange
2	France	Compagnie Francoise de l'Eau Lourde	Toulouse (a) Pilot (b) Industrial pilot	1955 1957	2·0	Liquid hydrogen distillation
3	India	Nangal Fertilizer and Chemical (Private)	Sutlej River near Nangal Dam	1961	14·0	Electrolysis of water combined with ammonia distillation
4	Switzerland	Emser Werke AG	Domat/Ems	1960		Electrolysis of water followed by the liquefying the hydrogen-deuterium gas mixture and then vacuum distillation

22. Comparative costs of heavy water

The principal producers in the world are the United States Atomic Energy Commission with plants at Savannah River and Dana, and Norsk Hydro at Rjuken. Before 1956 the United Kingdom Atomic Energy Authority and Canada obtained the heavy water at £75,000 per tonne. However, since 1956 the U.S.A.E.C. selling price has been $28 (£10) per lb, equal to £22,040 per tonne, which is 29·4% of the Norsk Hydro's cost. In April 1956 the U.S.A.E.C. sold at that price 129 ton to six nations for the peaceful use of atomic energy, as indicated below:

(a) United Kingdom	50 ton
(b) France	30 ,,
(c) India	21 ,,
(d) Austria	11 ,,
(e) Italy	10 ,,
(f) Switzerland	7 ,,

In January 1956 the U.K.A.E.A. announced that after consultation with the New Zealand Government it had decided to withdraw from the geothermal scheme at Wairakei which was planned in 1954 to generate electric power and heavy water. This was the result of a revised estimate of this plant which proved to be twice the original, the cost per ton of heavy water amounting to about £90,000 which is about four times the U.S.A.E.C. price. In the United Kingdom there are four experimental reactors, three at Harwell and one at Dounreay, that use heavy water either as moderator only or as moderator and coolant, as shown below:

Location	Reactor	Heavy water		Thermal rating	Date of start up
		Moderator	Coolant		
1. Harwell	Dimple	yes	no	100W	1954
2. ,,	Dido	yes	yes	10MW	1956
3. ,,	Pluto	yes	yes	10MW	1957
4. Dounreay	D.M.T.R. (Pluto type)	yes	yes	10MW	1958

To be continued.

Membrane Analogy for Determination of Stress Distribution

The discovery of an analogous relationship between the behaviour of the deflexion surface of a uniformly loaded membrane and the stress distribution in a twisted bar or rod was due to Prandtl. It can be put to considerable use for both theoretical and practical analysis of stress distribution problems which do not lend themselves readily to conventional solution. The practical form is particularly suited to more complex cases which cannot be, or are extremely difficult to analyse mathematically, with the advantage from the engineer's point of view that it is a purely physical method. Much of the original work in this direction was conducted by Griffith and Taylor

IN any member stressed in torsion the stress distribution through the cross section tends to generate a characteristic pattern. It is reasonably easy to establish the form of stress distribution in a simple or symmetrical section, but less so with other sections without resorting to photoelastic methods of stress coating techniques. Although these are later methods than membrane analogy, analogy technique still forms a useful analytical tool, although remaining comparatively unknown.

The basis of the analogy is that if a film or flexible membrane of homogeneous material with a shape corresponding to the cross section of the structural member (suitably restrained by a frame or similar device which gives uniform tension at the edges), the pattern of its deflexion under uniform lateral pressure will follow that of the stress distribution of a solid member loaded in torsion. Provided the deflexions are small this is an exact scale pattern where the gradient of the membrane (or, more specifically, the differential equation of the deflexion surface) is identical to the stress pattern in the solid member of the same cross section under torsion. The two are identical when the ratio of the lateral pressure causing deflexion of the membrane to the tensile force per unit length of membrane at the boundary line is equal to $2\,G\,\theta$, where G is the modulus of rigidity of the solid member and θ the angle of twist per unit length produced by torsional loading.

When this condition is satisfied it follows that the slope or gradient of the membrane at any point is equal to the magnitude of the shearing stress at the corresponding point in the solid member under torsion; a tangent to the contour line at any point on the membrane gives the direction of the shearing force at that same point in the solid section; and that twice the volume included by the deflected membrane is equal to the torque applied to the solid bar to produce an angle of twist of θ.

The simplest case is that of a circular cross section, where the analgous membrane is a circular film constrained at the edges by any suitable means by a uniform tensile force T which effectively stretches the film in position. If now the film is subject to a uniform lateral pressure P it will deflect in the manner shown in Fig. 1. Considering any portion of the film of radius r

(i) the total pressure on that portion will be $P \times$ area $= P \times \pi r^2$

At the same time the film will be deflected and thus the pressure will be balanced by the tensile forces T distributed around the perimeter of the circle of film radius r, acting tangentially to the deflected membrane. Hence the effective tensile force, acting against the pressure, will be

(ii) force resisting pressure $= 2\,\pi\,r\,T\,dh/dr$

where h denotes the deflexion.

Equating (i) and (ii), bearing in mind that they are opposite in direction and therefore opposite in sign

$$\pm P\,\pi\,r^2 = \mp 2\,\pi\,rT\,dh/dr$$

whence $-dh/dr = Pr/2S$

The left hand side of this equation expresses the slope of the membrane. Embracing the requirement that P/T should be equal to $2\,G\,\theta$ and substituting

(iii) $\qquad -dh/dr = \frac{1}{2}\,2\,G\,\theta\,r = G\,\theta\,r$

The right hand side of this equation is the standard form for the torsional stress in a circular shaft twisted through an angle θ, hence this is correctly expressed by the slope of the membrane. Similarly, the maximum slope of the membrane at any point is perpendicular to the radius at that point (consistent with the known direction of the shearing force in a solid circular shaft).

The equation of the membrane curve is given by integrating (iii) giving

$$h = \tfrac{1}{2}\,G\,\theta\,(R^2 - r^2)$$

It then follows that the volume included between the deflected membrane and the plane of its outline is

$$\text{volume} = \int_0^R 2\,\pi\,rh\,dr$$

$$= \tfrac{1}{4}\,\pi\,R^4\,G\,\theta$$

The torque corresponding to a deflexion θ in a solid circular section is equal to $G\,\theta\,I_p = \frac{1}{2}\,\pi\,R^4\,G\,\theta$, or twice the volume just calculated. Thus twice the volume enclosed by the membrane equals the torque.

Exactly the same form of analysis can be used to prove the validity of the membrane analogy for other typical solid sections subjected to torsional loading. In such cases the method has little or no advantage since direct solutions are readily available in the form of standard formulae. Where the solid section is irregular or complex, however, the membrane analogy may be applied to advantage actually to measure the stress distribution by plotting the contour lines of the deflected membrane under simple test conditions.

The method in this case is purely physical, typically using a flat plate with a cut-out section and a soap film for the membrane. This is then subject to a uniform pressure and the contours of the soap film plotted by

mechanical and/or optical means. A reference section (usually circular) is also included so that the exact relationship between measured and equivalent values can be established, the two sections being cut on the same plate and spanned by the same film and subjected to the same pressure—see Fig. 2. It then follows that both films have the same value for P/T so that the reference section and the test section have the same values of $2\,G\,\theta$. Measurement can then be conducted on a comparative basis (i.e. the test section stresses related to the standard section), or at an equivalent level by adjusting the deflexion of the standard section membrane by varying the pressure. Since the stresses at any point in a standard section can readily be calculated from standard formulae, comparative stresses in the test section are readily derived by factoring.

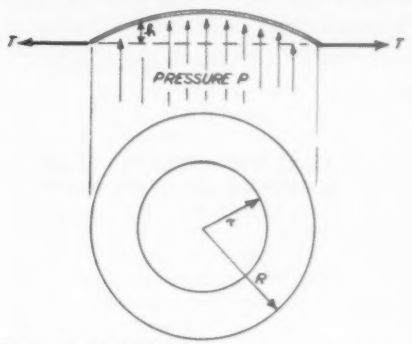


Fig. 1.—Circular film deflected by uniform pressure

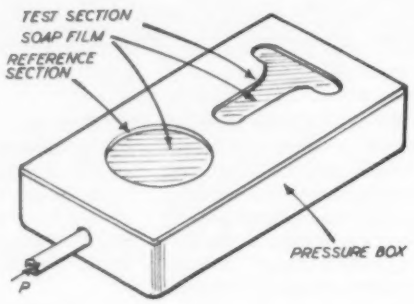


Fig. 2.—Test section and circular reference section mounted on pressure box

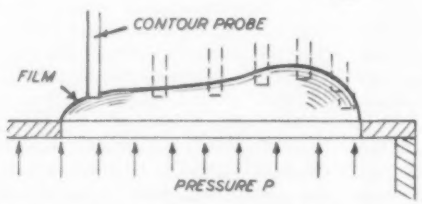


Fig. 3. (right)—Use of probe to measure membrane contour

Membrane contours can be plotted by mechanical measurement using a suitable device which can be adjusted in height to touch the film at various points. Traversing the film with a fixed height setting a number of contact points are established which can be plotted as dots and finally joined to represent a contour line. Repeating at various heights a complete contour 'map' can be produced—Fig. 3.

Provided the individual contours are closely spaced the slopes in the film can then be determined with a good degree of accuracy by measuring the distance between adjacent contour lines. For greater accuracy, however, optical methods are to be preferred for measuring slope, based on projecting a beam of light on the surface of the film in a normal direction and measuring the angle of the reflected beam. Optical methods can also be adapted to actual contour plotting. The main advantage of the mechanical method of measurement is that it can be done with quite simple and easily constructed apparatus.

Whilst the membrane analogy applies, basically, to torsional stress evaluation up to the yield point of the material it can also be used to investigate torsional stresses beyond the yield point, provided the (solid section) material deforms plastically beyond the yield point. To allow for the fact that the outer portions of the solid section will yield whilst the inner portion is still deforming elastically it is necessary to apply restraint to the ultimate deflexion of the membrane, consistent with the yield point of the material. Determination of the required form of restraint is, however, difficult for all but simple sections.

In the case of circular or square section shafts or bars subject to torsional loading the restraint required takes the form of a symmetrical cone or square pyramid, respectively, with constant slope corresponding, to scale, to the yield point of the material—see Fig. 4. When deflected by pressure the film assumes its normal curve until the pressure (and thus the corresponding stress) is equivalent to the yield point of the material. Any further increase in stress (pressure) then results in the outer portions of the membrane being restricted by the rigid back-up, corresponding to the onset of yield in this portion of the section whilst the remainder of the section continues to deform elastically. Thus the behaviour of the membrane continues to follow the true behaviour of a fully plastic solid section loaded in torsion beyond the yield point of the material, with a gradual progression of yielding through the section as the stress level (pressure) is increased. As before, the volume under the membrane is equivalent to one half of the torsion. It therefore follows that with a perfectly elastic material the ultimate or failure value of torsion is given by twice the volume of the restraining cone or pyramid. Since the slope of the cone or pyramid is equal to the yield point (f_y), we have

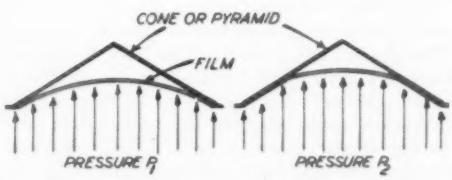


Fig. 4. (below)—Use of conical restraint to simulate combined elastic and plastic deflection

(i) in the case of a circular section and conical restraint:

$$\text{Volume of cone} = 1/3\ \pi R^3 f_y$$

This is one half of the theoretical value for the ultimate stress to produce failure with a perfectly elastic circular section.

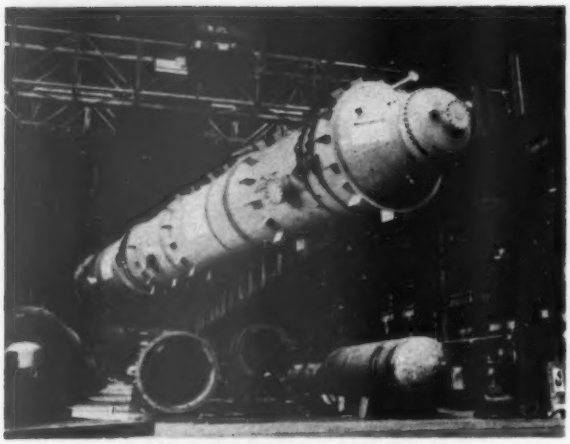
(ii) in the case of a square section and pyramid shaped restraint:

$$\text{volume of pyramid} = (D^3/8)\, f_y$$

which is again one half the theoretical ultimate stress value.

Scaffolding Castors

A new range of scaffolding castors by Flexello Castors & Wheels Limited, Slough, is designed for safety, long hard wearing use, and reliability. The scaffolding tube rests on a ball bearing swivel, and the castor is held in position by an extra strong steel circlip. This prevents the castor from falling out when one leg is not touching the ground.



Lubricants treating tower for the BP refinery at Kwinana, Western Australia

Lubricants Treating Tower

An 82 ft long lubricants Treating Tower has been manufactured at the Greenwich Works of G. A. Harvey & Co. (London) Limited for the B.P. Refinery at Kwinana, Western Australia. Made of $\frac{11}{16}$ in. steel plate the tower has an internal diameter of 8 ft 6 in. and weighs 49 ton. It was completed to schedule to the design and order of the main contractors, Foster Wheeler Limited, and before despatch was hydraulically tested to 148 psi. A second vessel for Kwinana, completed by Harveys at the same time, was a 66 ft long extract stripper and vacuum flash tower, 4 ft dia and weighing 12 ton.

Industrial Supercounter

A digital counter/timer/tachometer introduced by Research Electronics Limited, Bradford Road, Cleckheaton, Yorkshire is a general purpose tool primarily intended for mechanical and electrical engineering applications concerned with the measurement of speed of revolution, frequency, time, period and ratio. The "Supercounter" is of convenient, small size, light in weight and portable. The economical price has been made possible by construction from standard circuit modules which are already manufactured in quantity. The instrument combines the features of a frequency meter or precision tachometer for the measurement of events per unit time, a chronometer or electronic stopwatch for the measurement of elapsed time and period, a ratio meter for reading directly the ratio of, for example, two shafts rotating at different speeds, and a scaler or counter for totalling a number of regular or random occurrences.

Three input channels are provided

Channel A—Trigger stage and Principal Input. Input to counting chain and gating input in chronometer modes.

Channel B—START input for chronometer modes

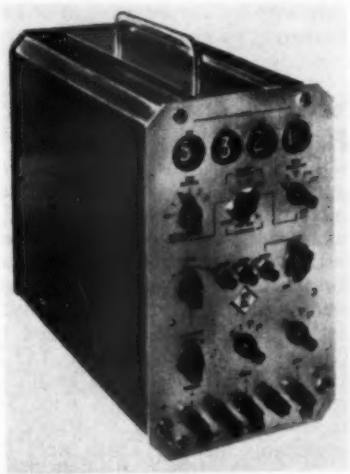
Channel C—STOP input for chronometer modes and second input for ratio meter modes.

These input channels with appropriate switching enable the instrument to be used in any of its basic modes.

It is often required to carry out certain measurements, particularly in chronometer and frequency meter modes as a continuous monitoring process. As it is inconvenient manually to reset after each sampling, an automatic reset unit is incorporated which automatically resets the instrument after a selected reading time has elapsed, permitting a new count to be initiated.

The instrument will count and total regular or random events over any period provided the events are signified by electrical pulses. These pulses may be of negative or positive polarity and if both are present on the one line the instrument may be set to count those of the desired polarity.

The instrument operates as a chronometer by feeding standard timing pulses into the counting chain for the duration of the time interval to be measured. The instrument 'locks' on completion of a reading and cannot be restarted until reset. This enables parameters of continuously repeating functions to be isolated and measured by providing 'single shot' facilities. The system of gating prevents spurious STOP instructions received after reset but before the correct START instruction from upsetting the correct operation.



The Research Electronics Supercounter—a general industrial counter/timer/tachometer

Welding Gas Mixture

Argomix—a high purity mixture of 80% argon and 20% carbon dioxide—is now being marketed by the British Oxygen Company Limited, London SW1. It is for welding mild steel by MIG (bare wire, gas shielded process) and can be used on sheet metal and heavy plate. Argomix takes the place of carbon dioxide or, in some cases argon/oxygen mixture, and has several operating and economic advantages. It is supplied in 240 cu ft cylinders at a pressure of 1980 psi. In sheet metal welding, with the new dip transfer technique, Argomix gives faster welding speeds with less spatter and a smoother profile. It operates at lower arc voltages than CO_2 and gaps can be bridged more easily. Similar advantages can be achieved in downhand and horizontal vertical fillet welding of heavy plate at high currents.

"Clearway" Indicators

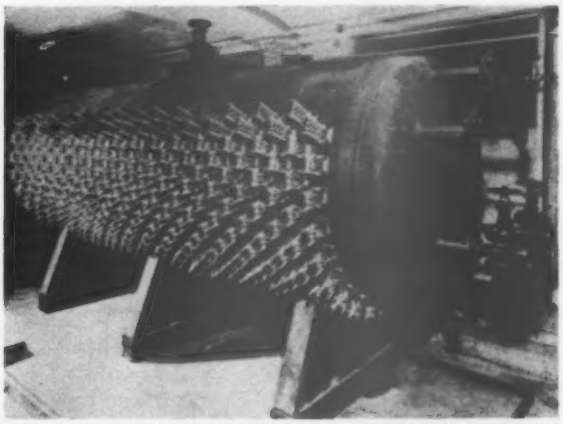
The range of 4 in. dial indicators for temperature, pressure and vacuum measurement made by Cambridge Instrument Company Limited, North Finchley, London N12, are to be marketed under the trade name "Clearway". Design features include open-scale markings and rimless perspex windows, making the instrument easy to read even where light conditions are poor.

Vacuum Forming Moulds

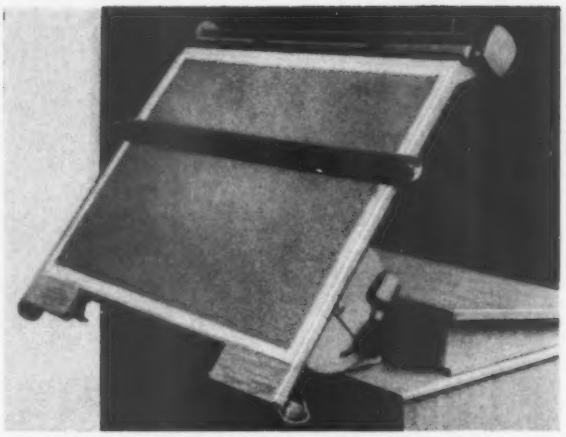
Vacuum forming moulds can be made quickly and inexpensively with Devcon C-2, a new heat resistant compound developed by Devcon Corporation, Danvers, Mass. A combination of 80% aluminium and 20% epoxy plastic, Devcon C-2 does not require pre-heating of the resin and hardener for mixing. The low viscosity of the material eliminates the formation of air bubbles or voids and makes possible flawless reproduction of fine detail. The hardened material has very good heat transfer, low exotherm and shrinkage of only 0·0014 in. per inch. Other advantages include long working life, no settling, high compression and high tensile and impact strength. The material can be machined with regular metal-working tools. In addition to making vacuum forming dies, it can be used for making embossing dies and for other applications requiring high strength at elevated temperatures. Devcon C-2 is packed in ⅞ lb, 4 lb and 15 lb sizes. Each unit is packed complete with the correct amount of hardener, release agent, measuring spoons and special instructions.

Steam from Test Equipment

When testing items of electrical equipment, the output generated is often wasted. This may be because outputs vary and cannot always be applied in a practical way to equipment which could take advantage of them. In an installation carried out by Heatrae Limited, Norwich, for Ferranti Limited, heat generated by testing equipment was utilized in a novel way. The equipment consists of a steel vessel designed to produce steam at 100 psi (in accordance with A.O.T.C. Class 2 requirements). It has an overall length of 16 ft 2 in. and an internal diameter of 4 ft 6 in. To this cylinder were applied a number of resistances, in the form of 579 immersion heaters. These were connected, in various series combinations, through control gear to absorb the output from electronic diodes during life runs of up to six months continuous duration. On maximum loads the resistances are required to dissipate a loading of just over 1000 kW, and the steam generated is used to augment the heating system in the factory where the tests are being carried out.



Resistances are shown assembled on steam vessel. On completion each terminal is surrounded by it own box and submerged in plastic heat insulation



The Mason Minor bench drafting stand

Bench Drawing Board Stand

The new Mason Minor Mark III drafting stand is without handles and knobs and the slide bars are mounted in nylon blocks and give an adjustment range of 14¼ in. The complete board mounting frame at all times ensures the free adjustment of the stand regardless of board expansion or contraction due to climatic variations and the hidden, constant rate counter-balance springs are neat and noiseless. The friction control system provides instant adjustment to suit requirements and small metal feet castings provide stability of the whole unit.

The smallest or tallest draughtsman can work in comfort at this assembly either standing or sitting. Rise and fall is by finger tip pressure and angular adjustment made instantly simply by pressure on the top or bottom of the board. Additionally, the board can be positively locked at any angle. Makers are E. N. Mason & Sons Limited, Arclight Works, Colchester.

Store Box System

The Erecto Slotted Angle Company, 101 Waterloo Road, London SE1, have commenced production of a new range of equipment, the "Store Box" system which provides a complete mobile storage system and enables materials to be conveyed in units from the stores to and from the production processes and finally back into the stores. The system is comprehensive and uniform throughout the factory. The boxes are in four different sizes and are manufactured from high impact polystyrene plastic and heavy duty hot dipped galvanized steel. They can be stacked one upon another without damage to the goods conveyed and when not in use can be nested in the minimum of space. The design of the box provides maximum accessibility and enables the contents to be seen at a glance. Galvanized steel dividers are provided which enable the two largest sized boxes to have two compartments and these boxes have separate card holders. To complete indentification, cards are supplied in four different colours and transparent plastic covers are provided. An accessory in the form of a frame unit is simply and quickly erected and can be easily and quickly altered to suit any change in requirement. When using more than two bays of frames in a continuous run, by using extension brackets alternate uprights are eliminated.

An example of the vari-angle series, a No. 35 V.C.B. fan. According to the way in which the casing and impeller are assembled the air can be discharged upwards, downwards or either hand

Variable Angle Fan

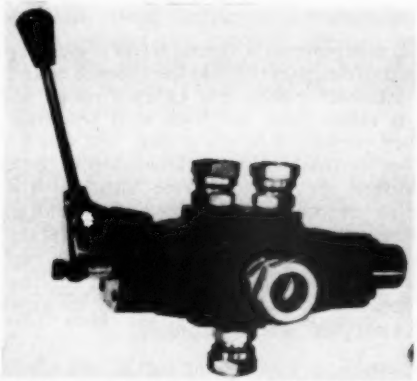
A revised version of their V.C.B. range of high efficiency centrifugal fans has recently been put on the market by Matthews and Yates Limited, Swinton, Manchester. The new range, known as the V.C.B. fan Vari-angle series, is designed so that the direction of discharge can be varied according to the requirement of the installation. The fan is so constructed that according to the way in which the casing, side frames and impeller are assembled the air can be discharged upwards, downwards, to the right or to the left. The modification will enable these fans to be made more readily for stock and thus delivery times will be reduced considerably. In some cases the customer would be able to carry out an alteration on site to convert the discharge from one direction to another. Initially, the range of this Vari-angle series will be in seven sizes from 4000–21,000 cfm for duct pressures up to 5 in. wg.

Superconducting Materials

Techniques have been developed by research scientists of Associated Electrical Industries Limited, for the production of niobium zirconium, one of the most efficient superconducting alloys, as wire drawn in sizes down to 0·005 in. dia. This development is of particular interest in the plasma physics field, where superconducting materials are required in a form suitable for winding as solenoids. Until recently, niobium zirconium wire has only been available from the United States. It is an extremely difficult alloy to draw as wire since it tends under normal conditions to stick in the dies. A.E.I. metallurgists, who are now producing niobium zirconium in very pure form, have a wide experience in the development of such unusual alloys as these special superconductors. Tungsten rhenium alloy, a superconductor which has been exploited in thermocouples, and niobium tin, have both been produced at A.E.I's Aldermaston Research Laboratory.

Control Valves

A new range of Mono-Radial piston type directional control valves was recently designed and manufactured by Andrew Fraser & Co. Limited, hydraulic engineers of 64-65 Vincent Square, Westminster, London SW1. Design feature is versatility—valve end pieces are interchangeable to facilitate adaption from hand to either tappet, pilot or pneumatic operation. In standard form, however, valves are operated by levers which can be moved round in 90° steps to suit particular installations. The valves in the range—known as Series C Mark 6—are available with either open or closed centre in neutral position. Open centre valves are fitted with spring return to neutral as standard; closed centre models are without spring, but incorporate detent in neutral position. All offer three and four way control. Body sections are of high duty iron; pistons are hardened steel. The valves have capacity ratings of 0–15 gpm in the smallest model to 60–100 gpm in the largest. Working pressures range from 2000 to a maximum 6000 psi.



Lever operated piston type directional control valve. Valves in the series have interchangeable end pieces to facilitate adaptation from hand to tappet, pilot, or pneumatic operation

Spotwelding Aluminium

Aluminium can now be successfully joined by means of the TIG (tungsten-inert-gas) spotwelding process, which has previously been used for joining steel and stainless steel sheet and thin gauge sections. The development of this technique into a reliable production state opens up new possibilities for exploiting the lightness and attractiveness of aluminium in a wide range of applications. Essentially, the process consists of striking an arc between a tungsten electrode and the top surface of the two overlapping pieces of metal to be joined. The duration of the arc is timed electronically to control the subsequent melting and result in a fusion spot penetrating through both pieces. Argon gas is supplied to a cylindrical nozzle surrounding the electrode to eliminate oxidation of the metal during welding. The advantages of the TIG spotwelding process are low cost, access to one side only of the joint is required, the portability of the equipment and its low power requirements. Using existing equipment Aluminium Laboratories Limited, Banbury—the research company of the Alcan Group—have developed techniques for the successful application of the process to aluminium joining for use in production by unskilled labour.

Hydraulic Test Vibrator

A new hydraulic powered vibrator developed by the Dowty Group of Cheltenham, Gloucestershire, will simulate vibration of any kind, and stresses taped from test runs can be played back through the vibrator for fatigue testing of equipment.

Thrust levels up to 100,000 lb are available, and as an indicator of performance obtainable a 4000 lb mass can be vibrated from 7 cps to 200 cps. The vibrator can be mounted in any desired attitude and is designed to react to large side loads.

Production Practice:

Centralizing a Cast Component
Air Testing Castings
Removing a Component from a Mandrel
Gauging Taper Shafts in the Lathe

By JOHN WALLER

SMALL components with cast bores present a problem to the tool designer because the absence of an accurate location diameter means that either a rough and ready spotting is taken from the bore with resulting glaring errors when the part is finally drilled, and which suggests to an observer that faulty workmanship is the cause of this condition, or an adjustable location is essential in order to overcome the degree of eccentricity that occurs when the holes are viewed in relation to the diameters and though there are frequently only small batches of parts needing this treatment, the use of this type of location is preferable and not so expensive if the tactics adopted here are applied.

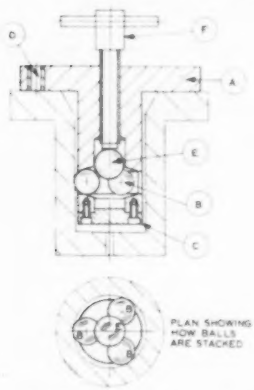


Fig 1.—Small diameter cast bores are located in this fixture by balls which provide the three-point spotting essential for rough surfaces

An added difficulty in the case where this problem was encountered was the "blind" nature of the bore as this prevented any form of stud passing through for tightening so it became necessary to use an expanding method of location and tightening with the pressure applied through the jig. Bore errors generally eliminate any suggestion of a tapered spindle and the only alternative is to use steel balls, and as a component having a cast hole demands a three point location, the spacing of this same number of balls equally round the circle provides a solution in that they give the necessary point location and do not take up so much room as the conventional locating pegs.

The body A (Fig. 1) is in two parts and consists of a long spigot in which a deeply bored hole has been internally shaped with a tool similar in shape to an internal Acme threading tool to give a cavity for the three balls B yet retaining a small wall to prevent them from falling from the body. The drawing shows the whereabouts of this latter portion which is finally secured when the three equally spaced holes are cross drilled to allow the balls to stand forth from the outside diameter of the spigot.

Dirt is prevented from entering the bore cavity by the cover C and this is held in place by small screws. A larger ball E and the clamping screw F complete the design. The last ball is put into the spigot after the clamping screw has been threaded in place as shown. Each of the smaller balls is then dropped in and by adjusting the screw they fall into their respective holes and remain there unless the clamping screw is withdrawn too much. However, by incorporating a restricting device on the screw this is easily prevented, but it is only really necessary when the number of components justifies the extra expense.

When air-testing to discover porosity in castings is permissible (it isn't always) the usual practice of stopping off the various holes requires blanking-off non-screwed plain holes. Fairly hard rubber is suitable material for a plug as it will overcome small discrepancies on the surface of the casting and avoid distortion where a hole is close to a side wall.

For large openings two rubber seals A and B (Fig 2) are preferable as this will make doubly sure that the hole is closed and yet the equipment remains light and easily handled. Both pieces are held between two brass plates C and D (used to avoid rusting) and a substantial bolt together with a hand nut will ensure that the rubber compresses and is also forced outward and makes contact with the component bore. The rubber performing this latter operation must naturally fit reasonably close to the bore of a component otherwise the lower part will not make contact before final compression. The rubber will cling to the bolt E used for clamping the parts, so the addition of a small silver steel pin F assembled through the hexagon head will overcome the turning motion which might occur on the lower plate.

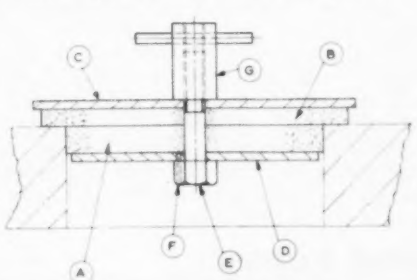


Fig 2.—Air testing with the aid of this type of rubber seal is easily accomplished as both the rubber discs effectively close the opening without the use of a heavy pressure

Seals of this design seldom require a greater pressure than is possible to exert by hand—the rubber spreads well and appears to be available in hard and soft variety

—so both parts flatten and spread round the opening and so stop air escaping. An overlap of about $\frac{1}{8}$ in. by the top seal is necessary for a hole up to about 6 in. dia. and slightly more for dimensions above this figure. Square and rectangular apertures are just as easily treated provided the inner piece of rubber fits closely to the component wall before pressure is applied by the clamping nut.

Heavy components having a small diameter hole for location purposes are often difficult to remove from a mandrel, especially if the latter is long, because the slenderness of the shaft means that bending is possible or, in cases of extreme tightness there is a danger of the mandrel snapping off when an attempt is made to pull the workpiece away. For such components a mechanical ejection is essential as this will slide the parts from the locating diameter without undue effort, and ensure that the force used will be in the direction of the spindle axis and without risk of deflection.

The barrel type component depicted in Fig. 3 has been heat treated, the bore diameter lapped to size and the outside diameter now requires turning and a thread cutting on the largest diameter. A faceplate A fits closely into the machine spindle and is bored and milled to accommodate the location spindle B, while a further pair of holes are drilled for the rods D. This faceplate is held to the spindle nose in the conventional manner—three bolts equally spaced—and this method prevents chips from entering the spindle bore and affecting the rods. Interposed between the faceplate and the component is a pad C the function of which is to transmit pressure evenly from the rods to the workpiece. In the drawing the pad is shown standing away from the faceplate slightly but in practice the pad is pressed back against

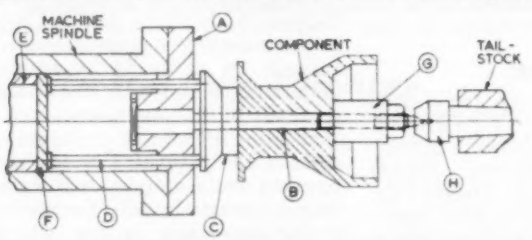


Fig 3 — Mandrels of this type are successfully used on both lathes and grinding machines providing care is exercised when applying the cutting pressure. A positive ejection is accomplished without fear of bending the mandrel—a condition not possible when attempts are made to pull the part away by hand

the plate and the component is thus located on a solid and positive surface. The thick washer G completes the assembly and overcomes the necessity of machining a special hexagon nut which is more expensive to make. The end of location spindle B is coned to suit a female centre as this form of construction gives a somewhat stronger bearing diameter than attempting to use the orthodox centre in a small internal cone.

The action of the pad originates with the sliding spindle E which is actuated from the rear of the machine by a handle or handwheel. The rods are sufficiently long to ensure that the pad will completely push the component from the location and even with the most stubborn details the pad never fails to eject a part satisfactorily and without any tendency to bend the location diameter.

A mandrel of this design is applied when the number of parts justifies the expense or when several unsuccessful attempts with a mandrel of the usual design has only succeeded in rendering them useless for further service, so the question of hardening will depend on the length of service expected. A hardened location spindle is generally essential as in addition to having to provide an accurate seating for the component, the end running in the female centre also needs this treatment otherwise the spindle can have but a short life. Casehardening of the pad is also advisable as continued pressure by the pins and component soon causes the surfaces to become pitted, but the rods and cover over the operating spindle can be left in the soft condition as these will seldom become damaged, and any raised burrs are unlikely to create problems.

Mandrels of this design have been made with a location diameter as small as $\frac{3}{16}$ in. with a component having an outside diameter of $1\frac{1}{2}$ in. being turned on it, and though in these instances considerable care is necessary to prevent the mandrel bending under the influence of the cutting pressure, it will successfuly machine details in this manner and thus ensure perfect concentricity of the diameters.

The accurate checking of tapers is not difficult when the workpiece is removed from the machine, but when the job is held in a chuck, any attempt to remove it and again reinstate it with exact concentricity is impossible without lengthy resetting, thus a device that allows an accurate check while the work is still in the chuck or between centres is useful because it economises in time and ensures that a component is not sent to the inspection department until the necessary accuracy has been achieved.

Essentially the device shown in Fig. 4 consists of a V-block with one parallel surface on which the micrometer is applied, and if the micrometer reading is

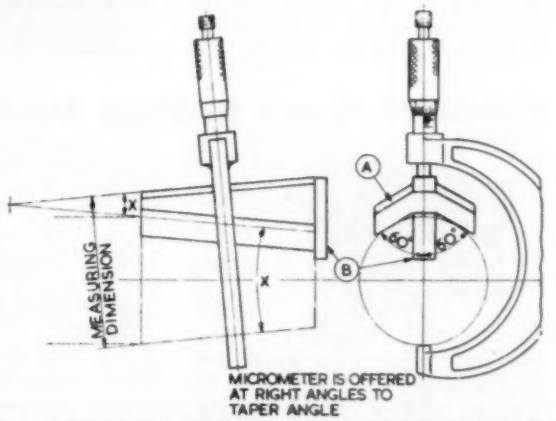


Fig 4.—A tapered V-gauge for checking a taper with a micrometer while the work is in the lathe. Measurement is made at each end for parallelism between top of gauge and bottom of taper

specified then checking merely involves measuring of block at each end.

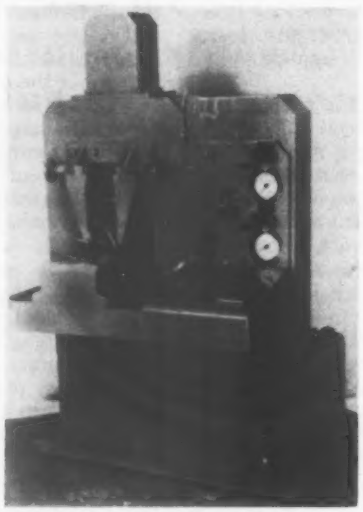
The micrometer is not at right angles to the lathe axis but is offered to the workpiece so that the fixed anvil is at right angles to one tapered surface. The body A is a tapered V rather in the nature of wedge, and after removing as much material as possible to keep the parts reasonably light, a small plate B is attached to the end by means of screws.

This latter serves as a stop—this is essential as without it the block slides along the taper and increases or decreases the micrometer dimension. Thus facing the end before machining the taper is required and once the gauge is applied to the shaft it will remain there while a check is made.

Machine Tool Record

Marking Press with Built-in Feed

The new E.P.60 automatic press made by Edward Pryor & Son Limited, Broom Street, Sheffield, 10, is capable of handling 2750 per hr of parts which require a marking load of up to 20 ton. It is provided with an intensifier which boosts the load up to 70 ton; at this load the operating speed is about 1100 parts per hour but this can be increased by fitting a larger hydraulic power pack. At the higher speed, the press is suitable for performing a combination of marking and countersinking operations on a wide variety of components. The countersinking is carried out by cold forming. Such parts as lock plates, ball bearing rings and small pressings can easily be handled.



New Prior 20-ton automatic marking press with 70-ton booster

The feeding mechanism is synchronised to the press by a camshaft operating the valve mechanism. Components are fed by spring pressure so that incorrect parts cannot cause any damage to the machine. The machine shown is arranged for magazine loading and as such it is easily adjusted. Vibratory feeders can be fitted which enable the machine to run without attendance for a longer period and allow one operator to feed two or more machines.

7/8-in. 10-Speed Drilling Machine

The "7-Eight"—the latest addition to the range of Fobco Star drilling machines

The manufacturers of the Fobco Star drilling machines, F. O'Brian & Company Limited, Crown Engineering Works, Swadlincote, Burton upon Trent, have now designed the Fobco "7-Eight", a robust, heavy duty machine with a 10 in. throat and 10 drilling speeds from 51 to 2650 rpm.

The head embodies a totally enclosed reduction gear box and cavities for contactor, push-button station and low-voltage lighting unit. Gears are heat treated steel and laminated fibre for quiet operation at high speed, mounted throughout on ball bearings, and an oil level indicator is provided. Speed change is by lever control.

The quill is bored No. 2 Morse taper, incorporates a multi-spline drive and is mounted on a matched pair of angular contact bearings and also a deep groove ball journal at the top .

A patented device is incorporated to simplify belt change and allied to this is the sectioned aluminium belt guard with fixed centre portion and front and rear sections on spring hinges, thus obviating the necessity of removing the belt guard to effect a speed change.

Elevating gear is standard equipment. The motor is a ¾ hp industrial type. The pedestal model with standard equipment is priced at £102. 7. 6d., and the bench model at £92. 7. 6d.

Copy and Co-ordinate Nibbling Machine

The range of Trumpf copy and co-ordinate nibbling machines will now shear steel plate up to 0·36 in. thick with the introduction of the latest model, the CN900. This machine is equally capable of straightforward operations such as shearing, nibbling, joggling, beading, flanging, folding, trimming and louvre cutting of mild steel, stainless steel, brass, copper, aluminium, duralumin and plastic materials.

As a copy nibbler it uses a template and tracer pin to shape blanks. The template is fixed to the table and the tracer pin, mounted on an adjustable copying arm, is guided around the edge of the blank. This movement is transmitted to the material carriage, which has free movement backwards, forwards and sideways. In this manner, the material is moved beneath the cutter in an identical pattern to the template. It is possible to nibble rectangular or circular cutouts from 0·48 in. up to 23 in. dia without a template or previous marking. Scales are provided for reference in these and similar functions.

The transverse guides of the co-ordinate arrangement have a working length of 52 in. or 80 in. but the latter is only used with the large supporting table. The total working area is 40 in. × 52 in. or 40 in. × 80 in.

A high nibbling rate is possible with the newly developed tools and special transmission gear. This allows a stroke adjustment of 0 in. to 0·40 in. independent of the number of revolutions or strokes which are infinitely variable between 400 and 1300 per minute.

The 3 hp main motor and two auxiliary motors are totally enclosed and surface cooled. The ram adjustment is by a geared motor unit with automatic brake. Control is by foot switch and reversing contactor. A graduated scale indicates the working position of the ram; top and bottom positions being adjusted by cams and

The Trumpf copy and coordinate nibbling machine will also carry out a variety of forming operations

graduated scale. Over-running is controlled by limit switches. Raising and lowering of the centre pin is by electric motor and controlled by reversing contactor and limit switches. Push button controls are provided for setting, and a pilot light indicates the position of the centre pin.

For universal sheet metal work a second toolholder is used which permits changes to be made in a matter of seconds.

The machine frame is welded steel plate and mounted on anti-vibration pads. No special foundations are required. It is motor driven and suitable for 400/440 volts, 3 phase, 50 cycles power supply. The sole distributors of Trumpf machines in the United Kingdom are F. J. Edwards Limited, Edwards House, 359-361, Euston Road, London, NW1.

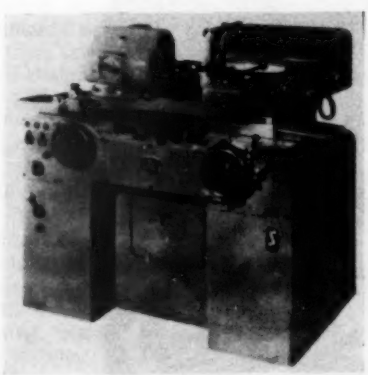
Bronx series BR5 adjustable angle reeling machine for straightening high tensile steel bars from ¾ in. to 2½ in. dia

Angle Reeling Machine

A bar reeling machine of the latest type made by The Bronx Engineering Company Limited, Stourbridge, which has gone to a customer in Switzerland incorporates features such as angular adjustment of the rolls to adapt the roll setting to the diameter of the bars to be straightened, two-motor drive (one motor for each roll), universal mill type couplings, and completely welded box type frame of rigid construction to avoid deflection. The machine will be able to straighten steel bars ¾ in. to 2½ in. The complete range of Bronx bar reeling machines incorporates a smallest machine with a capacity of ¾ in. bars and a largest one for bars up to 6 in. dia. Other machines not only straighten bars but can also be used for polishing bright bars.

Hydraulic Grinders

The Cerny hydraulic plain and universal grinding machines have automatic plunge feeds and automatic sizing. All machines in the range have hydraulically controlled stepless table speeds, wheelhead of improved design, simple centralized controls, and other features counting for greater productive capacity and high precision. Both plain and universal models are available with plunge feed, auto-sizing, and fully automatic cycle if required.—William Watts Limited, Canal Street, Nottingham.



Cerny hydraulic grinder with plunge feed and automatic sizing

Hailing from New Zealand this hand or power-driven sheet cutter will deal with flat or corrugated materials with equal facility

Cutting Corrugated Sheet

A new corrugated sheet metal cutting machine under the name "cuttermile" comes from a New Zealand firm, L. J. Fisher & Co. Limited, of Jellicoe Road, Paumure, Auckland. The machine cuts corrugated metals across, diagonally and lengthways without distortion and easily handles a variety of profiles; and makes clean fast cuts in hardboard, linoleum, formica, etc. Coiled strip metals can be sliced at speed continuously.

Normally hand-driven, the cuttermile can be turned over to power within 30 sec by merely sliding the handle off, and clamping on a ½ in. power drill. Two self-oiling steel gear wheels revolve self-sharpening cutters. A telescopic throat extends to 5 ft. permitting easy cutting of sheets up to ten feet wide, there being no limit to length cutting

Multipresses.—The agents for Denison Multipresses in Great Britain, Gaston E. Marbaix Limited, London SW11, advise that due to the success of the British built bench types, Denison Deri Limited, of Burgess Hill, are now building floor models ranging from 5 to 75 ton capacity.

Multi-purpose Milling Cutter.—The French Wista milling cutter is now sold in U.K. by Deltatone Limited, 30 City Road, London EC1. Any number up to six interchangeable carbide tipped side and face cutters are spline mounted on a common shaft.

Panel Sizer.—Laminated sheet is trimmed at the Glasgow factory of Ioco Limited by an automatic panel sizer made by Thomas White & Sons Limited, Paisley. Three longitudinal saws cut from below and three transverse saws from above in one operation.

technique

—devoted to the discussion of practical problems
Readers are invited to contribute items from their own experience in matters relating to design, manufacture and maintenance

Pressure Drying Propeller Moulds

Moulds for large marine propellers cast by Manganese Bronze Limited, are being forced dried with a Brown-Boveri electric pressure drier. The propellers which may weigh over 30 ton when finished, are cast in Nikalium to withstand corrosion, and the moulds must be uniformly dried and free from cracks or other defects to avoid any danger of subsequent rejects of expensive castings.

Brown-Boveri mould driers operate by forcing hot air through the sand and not merely over the mould surface. Drying is quicker and more efficient than can be achieved with hot gases from fuel-fired stoves. Using air temperatures some 100°C to 150°C lower than the hot gases, and less than one third the quantity of heat, they can reduce drying times by a half and in some cases by two thirds. The drying is extremely uniform throughout a mould; large cores can be inserted and dried at the same time so that castings can be poured without opening the mould.

The decision to install the drier in the company's works at Birkenhead followed a series of tests with a 70 kW unit providing air at temperatures up to 650°C which is forced through a mould by a fan rotating at a speed of 2900 rpm and having a capacity of 200 cu ft /min. Typical of the performance of this unit was the drying of a mould for a 5-bladed propeller having a cast weight of over 37 ton.

The drier now in use in the works is also a 70kW unit but the air temperature is limited to a maximum of 400°C and is pressurized by a fan having a capacity of 315 cu ft /min. It is a portable unit, it weighs 1400 lb and its overall size is 6 ft 10 in. by 2 ft 9 in. by 4 ft 9 in. high. In use it is placed in position over the centre boss after the mould has been closed as for casting. Hot air is then forced through the sand, the air pressure which is uniformly distributed over the whole mould depending upon the tightness of the mould and the permeability of the sand. The air gives up its heat to the sand and passes out through the ventilation channels saturated with steam. An absence of steam shows that drying has been completed.

The drying air is heated by being passed at great speed through ceramic tubes containing spiral wound heating elements. The tubes protect the elements and very good heat transfer is achieved. The fan is fitted with a radially bladed impeller and a diffuser, giving the advantages of both radial and axial type blowers. The control gear is mounted above the air heaters together with the single switch used to start the drier and to adjust the power input. Air temperature is controlled with a pointer-type mercury thermometer having adjustable minimum and maximum controls, which measures the temperature of the air entering a mould and switches elements on and off as necessary. A manometer is provided for measuring the static pressure in the mould and to prevent damage to the elements should the air pressure become excessive.

A second Brown-Boveri drier is being supplied to Manganese Bronze Limited by Foundry & Metallurgical Equipment Company Limited.

A mould for a 4-bladed 21 ton propeller about to be dried with the Brown-Boveri pressure drier seen suspended from the crane

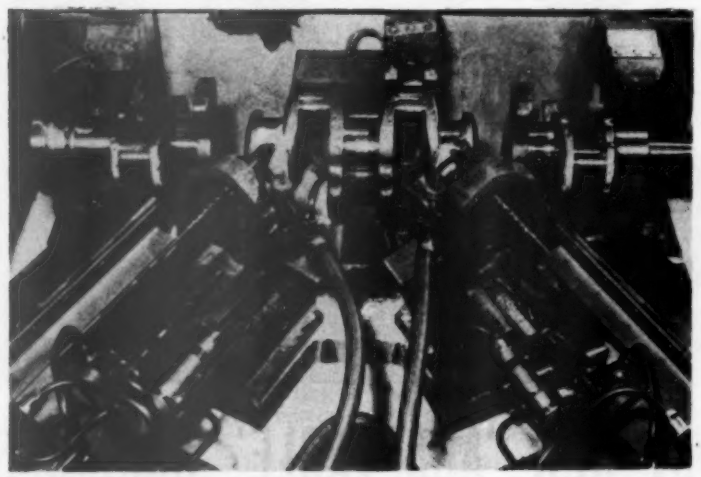
Rubber Lining Grooved Pulleys

A new type of rubber lined grooved pulley for supporting large bare conductors during the erection of overhead power transmission lines, has been developed by Dunlop in conjunction with British Insulated Callender's Construction Company Limited. Initial experimental tests were done by grinding a groove into a conventional solid tyre unit, but the degree of curvature was limited by the size of the tyres available and it became obvious from the early tests that lateral displacement of the rubber to any marked degree would not be acceptable. As a result it was decided to manufacture some special grooved pulleys and to have the grooves on these rubber lined. The primary object of the rubber was to protect the 2·214 in. dia steel cored aluminium conductors from damage due to crushing.

A 5 ft dia rubber lined sheave pulley was made to carry the conductors across the River Thames for part of one of the major permanent installations of the Central Electricity Generating Board in their Supergrid Network. The pulleys stood up with complete satisfaction to the drag and load effects applied and have recently been cleaned, examined and found suitable for re-use on similar work across the River Forth. In addition to the main pulleys, small idler pulleys were used on the ends of the booms to support the conductor in transit. These were also lined by the Dunlop Rubber Company Limited.

Automatic Machines Speed Crankshaft Drilling

To assist an increased production of industrial and automotive diesel engines at Leyland Motors Limited, three specialised drilling machines have been added to the crankshaft production lines in the factory manufacturing engine components. These new machines, designed and built by Leyland engineers, have a larger output than the machines previously used on this work and the machinist is less fatigued at the end of the day. They drill six ¼ in. dia angular oil holes from main bearings to crankpins, the holes being approximately 5 in. long from entry in the main bearing to break out in the crankpin.



Close-up of the crankshaft drilling operation on one of the three specialized drilling machines which has been installed in one of the Lancashire factories of Leyland Motors Limited

Each machine drills two holes and consists of a base casting on which are mounted two Kitchen and Wade unit heads, each fitted with a two-spindle indexing head. The crankshaft is held in a jig at the front of the base casting and the drill bushes are made to retract to ease loading and unloading.

The crankshaft is loaded with three of its main bearings located in half-round bearings in the jig, the axial location being on the centre main bearing. Radial location is accomplished by rotating the crankshaft until a crankpin is positioned against a hardened button. On starting the machine the crankshaft is pneumatically clamped and two housings containing the drill bushes are advanced to within ⅛ in. of the main bearing.

Both unit heads then advance with ¼ in. dia. slot drills in cutting position, and mill flats on the main bearings so that the ¼ in. dia drill, which is to follow, will have a facing at right angles to the centre line of the drill on which to make a true start. The unit heads retract and the two spindle heads index and advance again with the ¼ in. dia drill into working position.

To enable the drill to penetrate to a depth of 5 in., the drilling swarf must be cleared from the drill flutes. This is accomplished by a torque controlled electrical overload mechanism which retracts the drill completely, then returns to within a short distance of where it left off drilling, ready to commence drilling again.

When the hole is completed the unit head returns to its backwards position, the spindles cease rotation and the two-spindle head indexes bring the slot drill into working position ready for the next cycle. A manually operated pneumatic valve is then actuated which retracts the drill bush housings and unclamps the crankshaft, enabling it to be removed.

Each crankshaft is passed through all three machines, each machine drilling two holes. The machines are so interlocked electrically and pneumatically that machining cannot commence until the crankshaft is clamped, and unclamping cannot take place until machining is completed. Indexing cannot take place during machining, and machining cannot take place until indexing is completed and locked.

Making Gears by Knurling

A new method of making gears by the hot-knurling technique developed by Soviet specialists is now being introduced on a wide scale at the largest engineering works in the Soviet Union. A metal blank is placed in a special stand where it is heated to 1000°C by high frequency current. By means of a knurling device made of alloyed steel, teeth are formed on the hot surface of the blank. The Soviet engineers responsible for developing the new method have been nominated as candidates for a Lenin Prize.

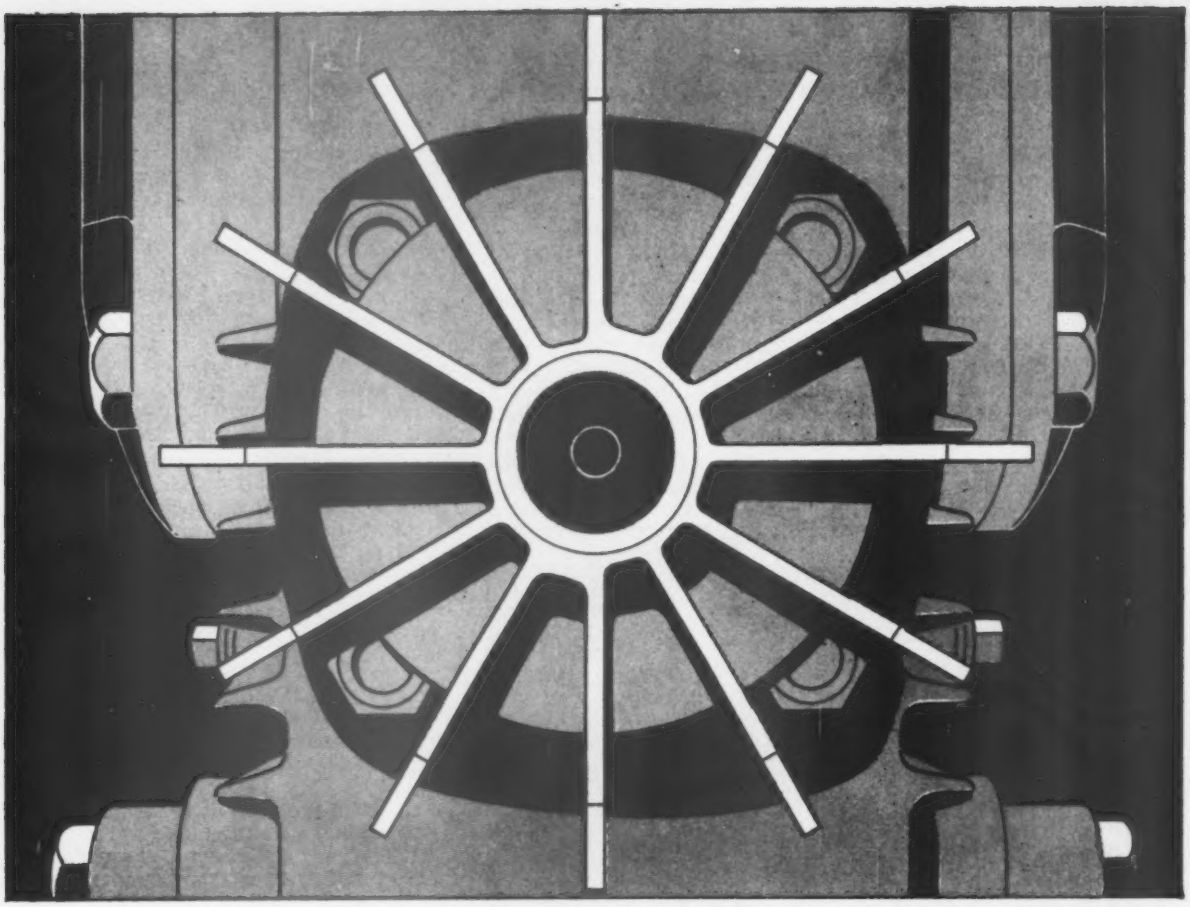
One of the members of the team, Mikhail Barbarich, told a Tass correspondent that the hot knurling technique is five to ten times more efficient than cutting. Gears made by the new method are said to be stronger and more resistant to wear. Moreover, a considerable amount of metal is saved.

A number of foreign concerns including Renault (France), and Itochu (Japan) have made enquiries about the possibility of using the technique under license arrangements with Soviet agencies. The gear knurling equipment is claimed to be simpler than conventional gear-cutting machinery, and to make gears with straight, helical and other types of teeth.

Low Heat Electrode Used for Cast Iron Reclamation

Design changes required a 1½ ton cast iron bedplate to be reinforced. This was achieved with complete success by cold welding in a cut-to-shape 1½" steel plate using Fontargen E116 electrode. No preheat of the casting was required. To obtain the required rigidity, 180 plug, groove and fillet welds were made. Using an 8 SWG electrode at 140 amp the welding was completed in 6 hr; 28 lb of electrode were consumed and the total cost was a mere fraction of a new casting.

Fontargen E116 electrode has been designed by Welding Improvements Limited, Northampton, for difficult welds on grey and alloy cast iron, for welding these metals to steel, and for surfacing and rebuilding cast iron where maximum bond strength and freedom from cracking are required. It has a core of nickel-iron alloy and the coating is formulated to give good flow and bonding properties even at low amperages.

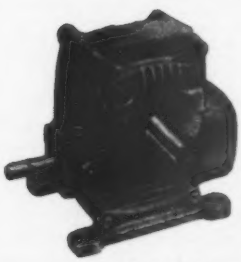


This is the reason why NEW 'ADAPTABLE' RADICONS have better than ever thermal ratings

This is the fan which David Brown have incorporated in the new Radicon 'Adaptable' range. The controlled flow of air increases heat dissipation, giving 50% more capacity over units of similar size without fans.

The 'Adaptable' range gives unequalled versatility of mounting because of its detachable feet. Seven sizes from 1¼" to 3⅜" cover drives up to 10 h.p. Leaflet E.387.125 gives complete information on sizes, performance and selection of the 'Adaptable' range.

For drives over 10 h.p. the SOLID FOOT RADICONS will meet your other requirements.



Both the design and name of the 'Radicon' are registered.

DAVID BROWN

100 YEARS 1860-1960

THE DAVID BROWN CORPORATION (SALES) LIMITED

An alliance of engineering specialists in gearing, machine tools, tools, castings, automobiles and agricultural tractors and machinery.

GEAR DIVISIONS, PARK WORKS, HUDDERSFIELD. TELEPHONE 3500

In Brief . . . .

Notes on New Materials, Plant and Machinery

Piston Valve.—Newman, Hender & Co. Limited, Stroud, are making a new valve to Bendix design in which a balanced piston actuated by external pressure source gives very fast on-off control, or can be accurately positioned to control pressure or flow.

Gas Turbine Fire Pump.—The South Shields Fire Brigade has become the first public service in the country to put a gas turbine water pump into service. It is a 50 hp. Perkins unit and will be used on the River Tyne, on fire floats or in any other boat or vessel as may be required.

Spiral Heat Exchangers.—Four spiral heat exchangers made by the Aluminium Plant & Vessel Company Limited, Crawley, have been applied in the extraction of penicillin, cooling a fatty acid product, cooling electrolyte in tinplate manufacture, and heating sludge in sewage works.

Flame Plated Drills.—An increase in the number of holes drilled per regrind from 200 with a normal drill to 18,500 with a flame plated drill is reported by Kearney & Trecker—C.V.A. Limited. Flame plating is done by Union Carbide Limited at Millers Road, Warwick.

Variable Speed Unit.—The German "Ringspaun" variable speed unit has been introduced into Britain by Henry Pels & Co. Limited, London NW1. It is of the variable pulley type, the pulleys having radial grooves and the link belt being provided with ribs to match.

Cold Working.—The new "Kold-Lube" process announced by R. D. Nicol & Co. Limited, Sheffield, provides dry film lubrication for metal undergoing cold working.

Constant Level Platform.—A spring controlled platform which keeps work materials and loads at a constant level has been introduced by W. C. B. Containers Limited, Audenshaw, Manchester. It can be either fixed or mobile.

Lift Truck.—The new "Coolie Cub" made by Polymathic Engineering Company Limited is a hand lift truck confined within 1 ft 10 in. It will lift 4 cwt to a clearance height of 4 ft 6 in.

Diaphragm Pump.—The new Layton DA4 2-in. diaphragm pump made by Henry Sykes Limited, Southwark Street, London SE1, will handle 6300 gph of water, slurry or pulp against 10 ft head, or 2160 gph against 100 ft.

Degreasing Plant.—MacCarthy Services Limited, 15 Sandhill, Newcastle upon Tyne 1, have introduced their new "Swurl" immersion type degreasing plant in which the degreasing agent is given a vigorous action to search out crevices.

Pumps.—Wayne Tank & Pump Company Limited, Western Road, Bracknell, have a new range of internal gear rotary pumps in capacities from 3 to 250 gph at pressures up to 100 psi.

Plasma Spraying.—Both high melting point metals and ceramics can be deposited on base materials by the new type 2MB Plasma flame spray equipment made by Metco Limited, Woking.

Dyline Prints.—An enlarger that will produce quality dyeline prints up to 30 × 20 in. from 35 mm film is supplied by Lawes Rabjohns Limited, Abbey House, Victoria Street, London SW1.

Electronic Timer.—A new series of timers for setting process or delay time quickly and easily has been introduced by The Donovan Electrical Company Limited, Northcote Works, Birmingham 33.

Miniature Recorders.—New 4-in. single trace and multi-point potentiometric recorders for measuring and recording any quantity which can be presented as a low level d.c. millivolt signal have been introduced by Associated Electrical Industries Limited, Harlow, Essex.

Speed Control.—Servomex Controls Limited, Crowborough, Sussex, have developed motor controllers which provide a speed range of 1000:1 combined with stability of the order of one part in a thousand.

Rust Inhibiting Paper.—Ungreased ferrous metal parts wrapped in Nox-Rust, a new chemically impregnated paper, are said to be in perfect condition after ten years. The paper is sold in rolls and sheets by W. H. Chapman Limited, Wellingborough.

Safe Pallet Stocking.—A new Randalrak stillage has a firm interlocking pallet base for quick and safe stacking in the 15 cwt range. Makers are James H. Randall & Son Ltd., Paddington Green, London W2.

Visual Flow Indicator.—The "Shaflo" indicator made by Parkinson Cowan Measurement, 7 Fitzalan Street, London SE11, shows at a glance whether liquid is flowing in a pipeline.

Hydraulic Control.—A new range of oil hydraulic control equipment has been introduced by Hydraulics & Pneumatics Limited, Villiers Street, Wolverhampton.

Blast Cabinet.—A new blast cabinet made by F. W. Berk & Co. Limited, Brent Crescent, London NW10, is complete in one piece with wiring, air piping and filter.

Control Valves.—A comprehensive range of ¼ in. and ¾ in. four way directional hydraulic control valves is manufactured by Oddy Engineering Limited, Leeds. They are for manual, solenoid, pilot or mechanical operation.

Plastic Balls.—Plastic precision seamless balls have a large number of industrial applications because of their shape, lightness, corrosion and abrasion resistance, non-magnetic and electrically non-conductive properties, and comparatively low cost. They are made in many sizes and materials by Insley Industrial Limited, 5 Windmill Street, London W1.

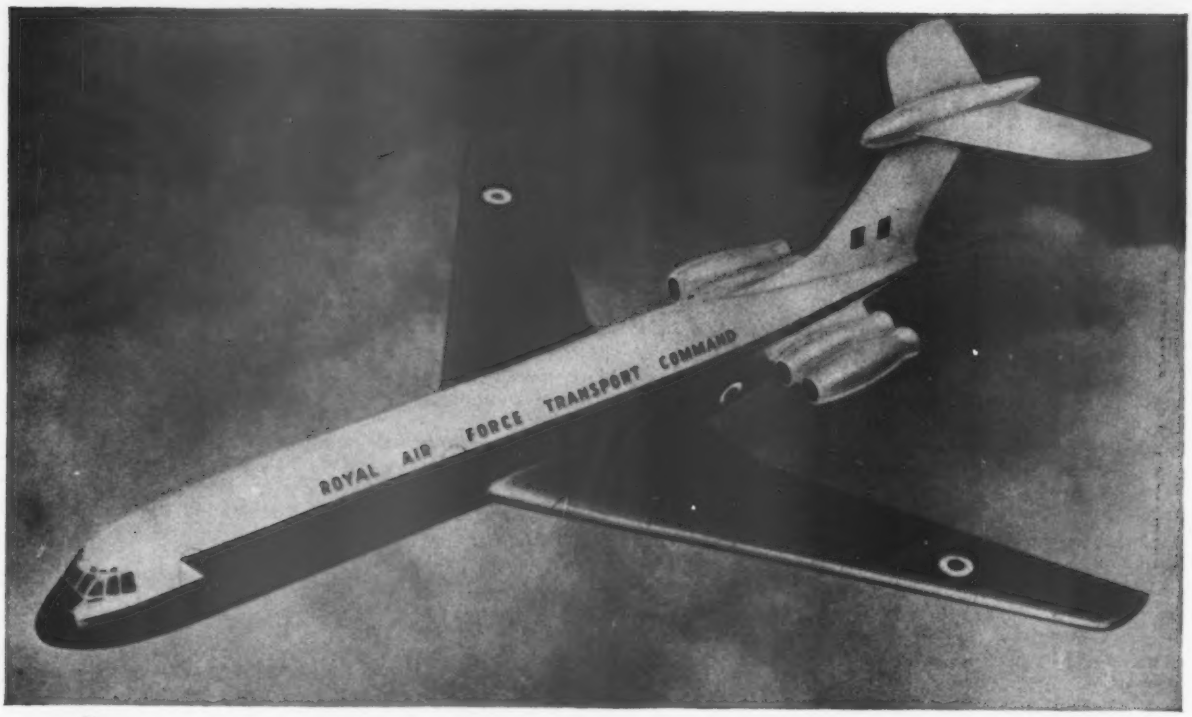
Do-it-yourself Radiators.—Glass fibre insulated radiators, control panels and other equipment are produced by K. Central Heating Systems, 250 Kingsbury Road, London NW9 for customers who want to build their own central heating installations.

Oven-Viewer.—An improved gas burner tube for the Elcontrol flame viewing head is now fitted to Darex ovens made by W. R. Grace Limited, Elvedon Road, London NW10.

Comparator.—A new comparator, the Heston magnoptic 6/60 projects a six inch field at ten diameters, or smaller fields at greater magnifications. Made by Heston Aircraft & Associated Engineers Limited it is marketed by Coventry Gauge and Tool Company Limited.

Lightweight Belt Conveyors.—To meet European competition G. Hunter (London) Limited, Grays, Essex, have designed a new range of light portable belt conveyors. Boom lengths are 3, 4 and 5 metres and belt widths from 300 to 600 mm.

Three-pass Boiler.—A new packaged boiler by Cochran & Co., Annan, Limited, is of 3-pass oil fired design with water cooled hemispherical rear chamber and tube plate. Initial sizes range from 2500 to 12,500 lb/hr.



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ROCOL MOLYDEST GREASE is used and recommended for all VC.10 assemblies where the capacity of ordinary greases is not sufficient.

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Rocol products are distributed in over 40 countries, manufactured in Australia by Rocol (Australia) Ltd., and under licence in France, Switzerland and Japan.

Materials for Engineering Production. By P. S. Houghton, London, 1962; The Machinery Publishing Company Limited. Part I, Vols. 1 and 2; Part II, Vols. 1 and 2. 20/- each volume (by post 20/10). approx. 190 pp. each, $5\frac{1}{2} \times 8\frac{1}{2}$ in.

The two parts of this work deal respectively with ferrous and non-ferrous materials and cover the various forms of cast iron, the standard steels (both B.S. En and S.A.E.) for manufacturing and for toolmaking, the aluminium and light alloys and the copper alloys, precious metals and a number of other metals including particularly all those of more recent significance and those for special purposes (bearings, solder, high temperature, etc.), and also timber and plastics and a group of sundry materials (diamond, cotton, glass, etc.). Many tabular data relating to compositions and mechanical properties are presented and there is much concise information on the origins, peculiarities, uses, treatments, etc., of all the materials dealt with. The scope is wide, the treatment adequate and the data apposite to the interests of the user of materials for engineering production whether he is in the board room, the design office or the workshop. The division of the work into four volumes makes the books of a handy size, and the subject matter has clearly been segregated, in the light of intimate experience, with as much regard to function as to kind.

Non-linear Systems of Analysis. Edited by R. H. Macmillan. London, 1962; Pergamon Press Limited. 17/6 net (by post 18/2). 174 pp. $5 \times 7\frac{3}{4}$ in.

This is the first volume to be published in the new 1000-volume Commonwealth and International Library of Science, Technology and Engineering launched by Pergamon Press. It is in paperback format but there is also a hardcase edition, priced at 30/-. It contains contributions by five authorities, commencing with a treatment of non-linear control systems by J. F. Coales and going on to the phase method by P. Naslin, the describing function technique and its application by John C. West, the computation of transients by P. Naslin, and autonomic control systems by R. H. Macmillan and N. W. Rees. Linear methods are seldom completely satisfactory for the analysis of control systems though they are useful for a first estimate. For present-day work the techniques explained in the book are really necessary because non-linearities so often greatly improve system performance. There is much on the subject in mathematical works, but in the present work the editor has collected the material and methods required in practice by the control engineer. Graphical methods are among the techniques explained and there is a chapter on the currently important subject of adaptive systems.

books

Centrifugal Pumps. By H. H. Anderson. London, 1962; The Trade and Technical Press Limited. 55/6 net (by post 56/8). 182 pp. $7 \times 9\frac{3}{4}$ in.

This book embodies the results of one designer's experience told briefly. He covers pretty well the whole field as regards pump types and applications (which is a guide to the kind of pump to contemplate for any given circumstances) and gives the steps, formulae and coefficients which he has found to be satisfactory. Testing too is similarly outlined, as also are the conditions and limits of mechanical designs. To the expert the book will doubtless be interesting, and the scientist will find it a valuable guide to empirical practice, and the well-tutored theoretician with no previous knowledge of pumps will find it an adequate guide to procedure. On the other hand it is no vade-mecum for anyone without experience of pump design, for there are no minutiae of detail that are not strictly relevant to the hydraulic aspect, or step-by-step calculation beyond the same limit: all else that is incidentally required the reader must himself provide. What it will certainly do is add greatly to the capability of anyone in process of acquiring the art and who is engaged upon or sufficiently in contact with the every-day work of a pump design office.

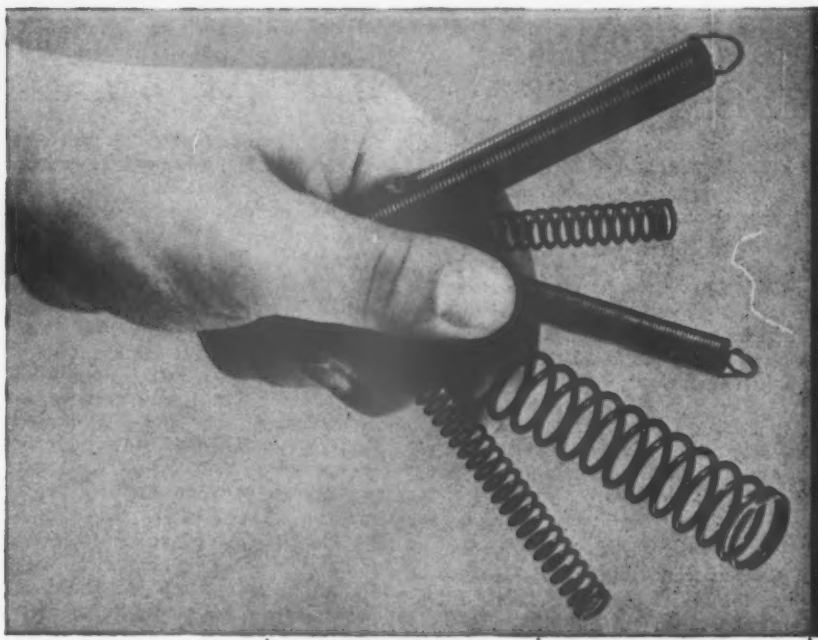
For the convenience of readers—

Books mentioned on these pages may be ordered by post through MECHANICAL WORLD Offices. Please state author, title, publisher and price by post when ordering.

Mechanical World Offices: 31 King Street West, Manchester 3.
158 Temple Chambers, Temple Avenue, London, E.C.4

Accidents at Drop Forging Hammers.—Unexpected falls of drop forging hammer tups result in crushed hands and other serious injuries, and methods by which these accidents can be prevented are described in "Drop Forging Hammers: Props and Catches" (H.M.S.O. 1/- net) a new booklet in the Safety, Health and Welfare series published by the Ministry of Labour. Efficient supporting devices can make an important contribution to the prevention of such accidents, and it is hoped that this publication will result in the provision and use of the most appropriate prop or catch for every hammer. The greater part of the booklet is devoted to illustrations of such devices for hammers with friction lifters, which lack hold-up gear. These include counterbalanced and biased props, fork catches and loose props, and it is suggested that the best support is provided by the counterbalanced or biased type. Mechanical props should be used wherever practicable during production work: in the few instances where loose props are justified the prop should be properly designed, secured to prevent movement during the work, and attached to the hammer when not in use. It is also recommended that where movable propping gear is required on board hammers, steam and air hammers and friction lifters with hold-up gear, specially made loose props, captive to the hammer, should similarly be used. Advice is given on safe methods of work at hammers, and emphasis is laid on the importance of effective maintenance, whatever supporting device is adopted. Frequent examination and overhaul are essential. Attention is also drawn to the need for newcomers to the industry to be effectively trained in the correct placing of props, and in the recognition and reporting of defects.

Helping Industry to Apply Research.—The ways in which industry can be helped and encouraged to apply the results of scientific research was the main concern of the Department of Scientific and Industrial Research during 1961. Commenting on the increasing activities of the Department, the Council for Scientific and Industrial Research, in its Annual Report (H.M.S.O., 4/- net) says: "We hope that by economic studies of research requirements, by the award of development contracts, by the continued support of Research



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No. 757. Extra Light Compression, 1 gross Assorted, ⅛" to 7/32" diam., ½" to 2½" long, 27 to 19 S.W.G. **18/-**

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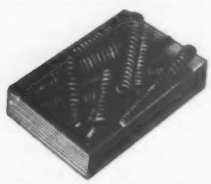

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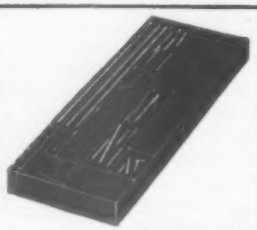

No. 1217. One gross Assorted springs. **45/-**

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Pick the spring you want, when you want it, from our fine range of small Boxed Assortments of Experimental Springs. We can show you only a few from the range here. Send a postcard for our full list—and if ever you're stuck with a Spring problem our Research Department will be pleased to put their long experience at your disposal.

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Associations and by the work done in its own research establishments, the Department makes a significant contribution to increased industrial efficiency and, therefore, higher productivity." The Department has been supporting by grant-aid six regional technical information centres—in Birmingham, Bristol, Liverpool, Manchester, Newcastle and Portsmouth. At the same time the DSIR branch offices in Edinburgh and Cardiff are devoting more time to this kind of work and a regional technical information centre is run by the Royal College of Science and Technology in Glasgow. Another method used to disseminate technical information from DSIR Stations and Research Associations is the production of a range of special publications—usually short books and leaflets—presenting up-to-date and valuable information in an attractive and easily readable form. Information activities are also carried out on a growing scale by the National Lending Library for Science and Technology and by a grant-aided body—Aslib (formerly Association of Special Libraries and Information Bureaux). The NLL, which was set up by DSIR in new permanent quarters at Boston Spa, Yorks., last year, is expected to become fully operational in the autumn.

Composite Construction for Steel Framed Buildings.—A new brochure of this title is supplementary to brochure No. 15 and presents for the assistance of the designer, the sectional properties of a further range of composite sections suitable for use in steel framed buildings. The use of concrete floors and steel beams in composite construction, wherein all or most of the compression due to bending is taken by the floor slabs and the tension taken by steel beams will result in considerable reduction in the weight of steel used for beams. The beams upon which the tabulated data has been based are 12 narrow flange universal beams and 6 joists all of which are included in B.S.4: Part 1:1962. The tables have been prepared for alternative modular ratios of 10, 12, 14 and 15 and for slab thicknesses of 3 in., 4 in. and 5 in. The brochure is available from the Director, British Constructional Steelwork Association, Artillery House, Artillery Row, London, SW1, at 3/6 per copy, post free.

Basic Wages and Hours.—Answers to many questions about minimum or standard rates of pay, or the length of the normal working week in more than 200 industries and services in the United Kingdom are to be found in "Time Rates of Wages and Hours of Work", (H.M.S.O. price 21/- net). This new edition, which revises the 1961 volume, has nearly 300 tables, including several which appear for the first time, and is compiled by the Ministry of Labour. In addition to current time rates of wages and hours of work, summaries give particulars of the basic rate for piece workers, additional rates for shift and night workers, and of arrangements, if any, for a guaranteed weekly wage or period of employment.

BISRA and its work.—The British Iron and Steel Research Association is a voluntary association of companies joining together for the purpose of carrying out research of general interest to its members. In iron and steel it is responsible for about one fifth of the total research and development work of the industry and has an annual income in the neighbourhood of £1M. It is a large concern with a staff of some 600 and therefore conducts a scheme of continuous recruitment. The qualifications and conditions of entry are set out in a very interesting way in a newly issued brochure which also gives a comprehensive picture of the association and its activities. The address is 11 Park Lane, London W1.

New Standards

Double-insulated All-insulated electrical equipment (B.S. 2754) Price 6/-

In this new edition the scope has been extended to include all-insulated as well as double-insulated electrical equipment. This is a memorandum and not a specification. It sets out the principles of design, explains how these principles are applied in connection with various points of detail, and recommends dimensional and test requirements. Also set out are the technical requirements which should be included in a specification for a particular type of equipment in order to give the standard of safety and reliability necessary to qualify it for recognition by the Institution of Electrical Engineers. The term "extra insulation" applying to all types of insulation used in Class II has been rejected as imprecise and unnecessary, and the use of reinforced insulation, accepted on the Continent as an alternative to double insulation, is strictly limited and should be used only in parts of double-insulated equipment where the use of double insulation is manifestly impracticable. Because of the importance of thorough testing and inspection of all-insulated and double-insulated equipment, the memorandum recommends that a specification for equipment should require it to be the subject of a certification scheme such as is provided by the British Standards Institution of the British Electrical Approvals Board.

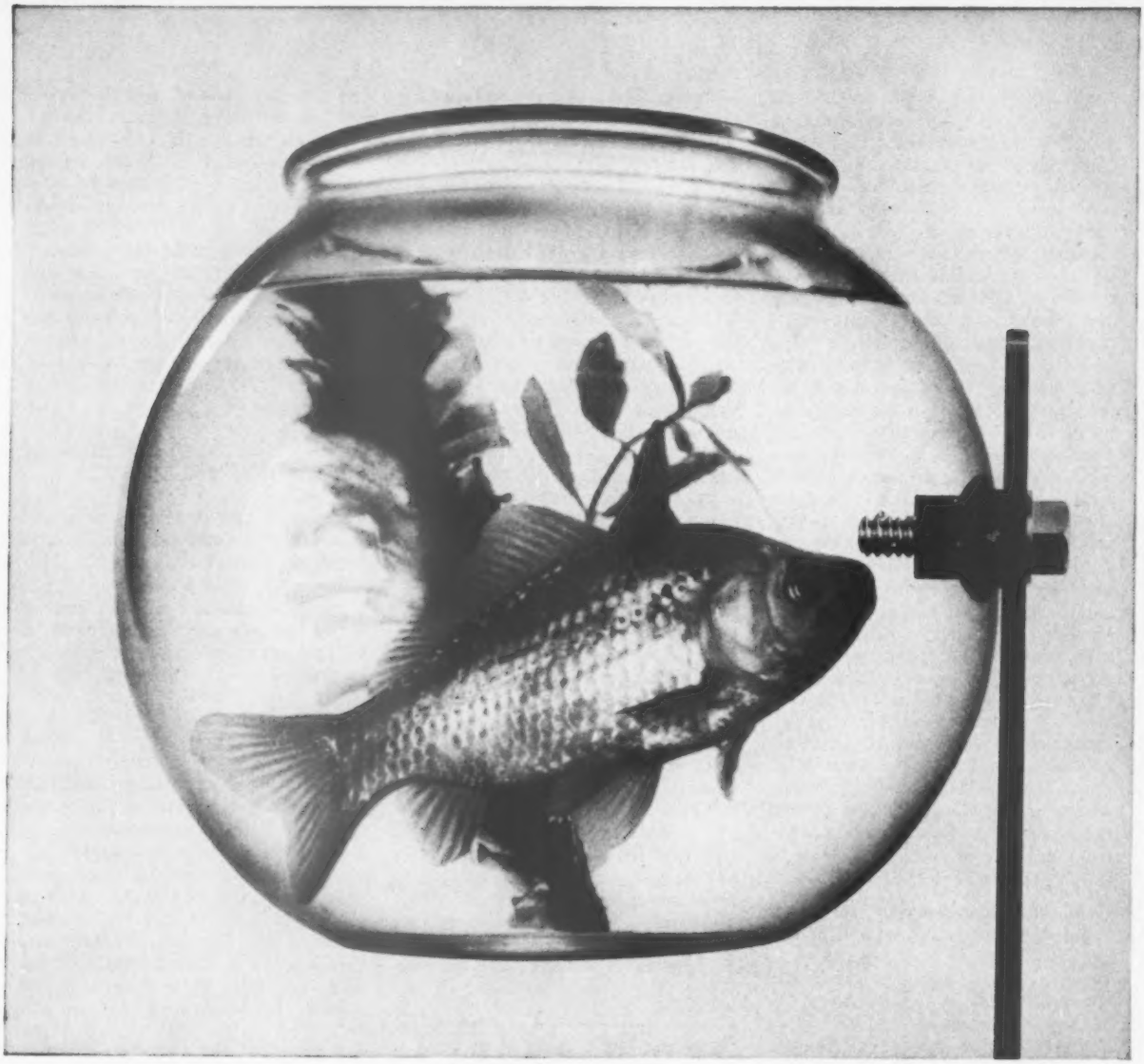
Register of colours of manufacturers' identification threads for electric cables and cords (P.D. 2379) Price 4/6.

Most specifications for electric cables require the manufacturer to be identified throughout the length of the cable. A convenient way of doing this in some of the smaller cables is to include a combination of coloured threads, each manufacturer using a different colour combination. The British Standards Institution is the issuing authority for such colour combinations in the United Kingdom, and the co-ordinating authority for the Commonwealth and South Africa. New editions of the register of colour combinations kept by the B.S.I. are published from time to time, and the fifth has just appeared. In it the colour combinations used by Canadian cable makers are given for the first time. These are compatible both with the Commonwealth scheme administered by the B.S.I. and with the scheme administered by the Underwriters' Laboratories in the United States. There is as yet no general co-ordination between these two schemes or between them and schemes used in Continental European countries and other parts of the world.

Hand-operated geared ladles for steel foundries (B.S. 3511:1962) Price 5/-

This standard specifies materials, construction and dimensions for hand-operated ladles up to 10 ton capacity, suitable for steel foundry use. The ladles may be supplied either for bottom-pouring, lip-pouring, teapot spout or suitable combinations of these.

British Standards Institution, 2 Park Street, London W1.



The one that didn't get away

. . . and never will, because that bowl is screw-fixed—right through the glass! The hole was drilled by a Rawlplug *Durium* Glass Drill, then a Rawlnut inserted and screwed up to form its own water-proof 'rivet-head'. And all this was done from the *outside* of the bowl. This unlikely example serves to highlight the supreme practicality of all Rawlplug Fixing Devices. They turn the 'difficult' and 'impossible' into routine fixing jobs, done in a minute and done for always. There's a Rawlplug device for *every* kind of fixing.

RAWLPLUG **FIXING DEVICES**

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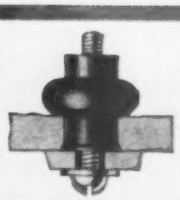
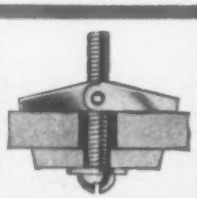


RAWLNUTS
The screw-fixing that forms its own 'rivet head' behind the material when screwed up from the front. Vibration proof, waterproof and insulative.



SPRING TOGGLES
For making firm fixings to thin materials—lath and plaster, plasterboard etc. The wings of the device spring apart behind the material and spread the load.

RAWLANCHORS
A fixing which enables screws to be withdrawn and replaced at will in wallboards, plaster boards, plywood etc. For prefabricated buildings, Rawlanchors can be fixed in the factory.

BUSINESS & PROFESSIONAL

Personal

ASSOCIATED ELECTRICAL INDUSTRIES Limited announce that **Mr. C. P. Holder, B.A., M.I.E.E.**, has been appointed divisional director and general manager of the Instrumentation Division, Associated Electrical Industries Limited. **Mr. R. S. D. Bagnall** has been appointed divisional commercial manager. **Mr. N. Ryland-Davis,** previously divisional general manager of the division, is appointed to special duties in AEI in addition to his directorships of Davey-AEI Automation Limited, Sunvic Regler G.m.b.H. and Birka Regulator G.m.b.H. **Mr. L. V. Smith, A.M.I.E.E., M.I.W.M.**, has been appointed staff manager (Manufacturing), AEI (Rugby) Limited. He succeeds Mr. J. S. Borrington who has retired from the position after thirty-four years service with the company.

Mr. Stanley W. Hoskins, A.M.I.MechE., M.I.P.E., Assoc.R.I.N.A., has retired from the board of I. V. Pressure Controllers Limited, a company which he formed in 1951. His services as consultant will be retained. **Mr. John Armour Smith, Assoc. M.Inst.B.E., M.Inst.M.S.M.**, has been appointed to the board as sales director.

Mr. J. A. Walton has been appointed area manager for South East and Central London region by Lancashire Dynamo Electronic Products and Lancashire Dynamo Nevelin, both companies in the Metal Industries Group.

Mr. W. Jack has been appointed a director of Hopkinsons Limited with whom he holds the position of Controller.

Mr. W. J. Moriarty has been appointed export sales manager of the Manchester engineering firm B. & S. Massey Limited, makers of forging and drop forging plant. Mr. Moriarty will continue to represent the company in the Midlands and the South.

Mr. C. B. Flindt, B.A., Cambridge, A.M.I.E.E., A.F.R.Ae.S. who joined the development division of R. B. Pullin 4 years ago has recently been appointed chief engineer of the company under Dr. R. H. Barker the technical director.

Mr. F. J. Auton has been appointed export sales manager of Associated British Machine Tool Makers Limited, 17 Grosvenor Gardens, London, SW1.

GEO. SALTER & CO. LIMITED, spring and spring balance makers, have appointed **Mr. L. A. Hoefkens** to be works manager of their Spring Road (Smethwick) factory.

PEGSON LIMITED of Coalville, Leicestershire, (a member of the Bentley Engineering Group) announce that **Mr. E. W. Somerville, A.M.I.MechE., M.I.Mar.E., M.I.W., A.M.S.M.**, has been appointed executive director.

Mr. M. G. O'Leary, B.A.Sc., general works manager, Alcan Industries Limited, has been appointed to the board of directors on the resignation of **Mr. C. T. Cornelius,** who has returned to North America to become vice president and general manager of Alroll Inc., of Oswego, New York.

THE BOOKER GROUP announces that **Mr. John Raymond, M.I.E.E.** has been appointed a member of the board of Bookers Engineering and Industrial Holdings Limited and deputy chairman of its subsidiary company Sigmund Pulsometer Pumps Limited.

Mr. G. E. Reynolds has been appointed sales manager of United Steel Structural Company, Scunthorpe, a subsidiary of The United Steel Companies Limited, in succession to the late Mr. S. Richards, who died last month. **Mr. H. N. Sayer** has been appointed assistant sales manager of the Structural Company.

Mr. Alan Barraclough, C.B.E., B.Sc., M.I.E.E., M.Am.I.E.E., has been appointed deputy general manager—export sales for The English Electric Company.

Mr. Wilfred Fry has been appointed to the board of Consolidated Electrodynamics Corporation (U.K.) Limited, Commercial Road, Woking, Surrey, as marketing director.

Mr. L. F. Cooke, sales manager of Cambridge Instrument Company Limited, has been elected to the board.

Mr. T. Nicholson, for 20 years works manager of Moon Brothers Limited, tin box and steel drum plant manufacturers of Birkenhead, has been elected to the board of directors. This appointment follows the recent retirement of his brother, **Mr. W. Nicholson,** after 50 years service with the company. A new works manager, **Mr. E. A. Hewitt, A.M.I.Prod.E., A.M.I.M.W.,** with many years practical experience in this field, has been appointed.

Mr. Charles W. Page has been elected a director of Castrol Industrial Limited.

HALL & PICKLES LIMITED, of Manchester and Sheffield announce the appointment of **Mr. Richard Hall** as a director of the company.

THE INTERNATIONAL TWIST DRILL COMPANY Limited, a member of the Tap & Die Group, has appointed **Mr. D. Clifford** as sales manager. Mr. Clifford was formerly Birmingham area manager. He is succeeded at Birmingham by **Mr. F. Brennan.**

Obituary

WE regret to record the death of **Mr. F. Lee,** a director of Laurence, Scott & Electromotors Limited. Mr Lee joined Electromotors Limited as a boy well over fifty years ago. A few years after the amalgamation of the company with Laurence Scott & Co. he was appointed general manager Manchester, and in 1942 moved to Norwich.

WE regret to record the death of **Mr. A. C. Mayell** home sales manager of Ransomes and Rapier Limited.

WE regret to record the death of **Mr. Norman Burney, B.E.M.** Mr. Burney was Perkins Group's longest serving employee, and helped to build the first diesel engine produced by Mr. Frank Perkins at Peterborough in 1932.

WE regret to record the death of **Mr. John Everard Stubbs, B.Sc.(Eng.) Hons., A.M.I.E.E.**, engineer-in-charge of projects, AEI Switchgear Division, Trafford Park. Mr. Stubbs joined Metropolitan-Vickers Electrical Co. Limited in 1926, as an apprentice in the Switchgear Department.

WE regret to record the death of **Mr. G. A. Wauchope,** joint managing director, Gwynnes pumps Limited.

Addresses

ALL the AEI District Office staff in Leeds serving the AEI Product Divisions now operate from—Siemens House, Sheepscar Street South, Leeds 7. Telephone No: 36951 AEI-Hotpoint Limited and AEI Lamp & Lighting Company Limited continue in their present premises.

METAL INDUSTRIES LIMITED has removed its registered office and transfer office, previously at 242 West George Street, Glasgow, C.2, to 104 West Campbell Street, Glasgow, C2. The head office of the company remains at Brook House, Park Lane, London W1.

H. WOOLLACOTT & CO. (GEAR CUTTERS) Limited, Worsley Gear Works, Mosley Road, Trafford Park, Manchester, 17, have taken over the good-will of Midgley Brothers of Kirkley Street, Salford, as a result of the retirement of Mr. Ernest Midgley and the closing of their works.

ROLATRUC LIMITED now occupy larger premises at Industrial Estate, Stirling Road, Slough, Bucks. Telephone No. Slough 27365/6.

GAS PURIFICATION & CHEMICAL COMPANY Limited, have moved their London offices to more extensive premises at North-West House, 119/127 Marylebone Road, London

HACKSAW BLADES

never let you down

'Eclipse' hacksaw blades and other tools are made by James Neill & Co. (Sheffield) Ltd. and are obtainable from all tool distributors.

UH 65

NW1. Tel. AMBassador 6671/0. Associated with this move will be three member companies of the Group—A. B. Metal Products Limited, Smart & Brown (Connectors) Limited and Wolsey Electronics Limited.

As from July 1 all polyvinyl and nitrile materials produced by British Geon is sold under the single trade name 'Breon', instead of 'Geon' and 'Hycar' respectively.

SQUARE D LIMITED have moved into their new office and factory building. The postal address remains unchanged. The telephone number is SWINDON 6222. They are now on Telex and all cablegrams should be addressed Squareli, Swindon.

THE new address of J. Cochrane Limited, Sheet metal goods manufacturers, is 61 Constitution Street, Leith, Edinburgh 6. Telephone—Leith 2944.

FISONS LIMITED announce a change of name of their subsidiary, Loughborough Glass Company Limited, to Fisons Scientific Apparatus Limited.

Contracts and Work in Progress

ASSOCIATED ELECTRICAL INDUSTRIES Limited.— *Switchgear Division.* Contract worth approximately £1m from C.E.G.B. for 400-kV switchgear for the new indoor substation at Connahs Quay, North Wales. *Motor and Control Gear Division.* The Dunlop Rubber Company Limited, has placed orders approaching £500,000 for the supply and erection of electrical equipment for two new tyre factories. One will be built at Kuala Lumpur in Malaya and the other at Ikeja in Nigeria.

ROYCE ELECTRIC FURNACES LIMITED, Woking, Surrey.—Supply of a continuous sintering furnace to Merisinter Meridionale Prodotti Sinterizzati S.P.A., of Naples, Italy.

G.E.C. (Engineering) LIMITED. Order, valued at over £21,000, from Wilkens and Devereux (Purchasing) Limited, acting on behalf of the Cyprus Mines Corporation, for a 7 ft. diameter 16 ft. long blade mill and two Eliptex screens. The mill is designed to wash pyritic copper ore at a rate of 140 tons an hour.

THE ENGLISH ELECTRIC COMPANY LIMITED. —Contract for the construction of Peru's largest power system (value £30m.) obtained from the Peruvian Government by an international consortium formed by The English Electric Company Limited, George Wimpey & Company Limited and Siemens-Schuckertwerke A.G. of West Germany.

Order for 28 transformers worth more than £4m placed by the C.E.G.B.

Contract value £700,000 signed at the Poznan Trade Fair by English Electric and the Polish Trade Company Elektrim, covering the supply of four 410,000 volt auto-transformers for the Polish national grid.

MATTHEWS & YATES LIMITED, Swinton, Manchester.—Contract for ventilation equipment obtained through English Electric Company Limited for a new £60m. steelworks, to be built in Rotherham by Tube Investments, Limited. The works will be sited adjacent to the Park Gate Iron and Steel Company Limited, a T.I. subsidiary.

WICKMAN MACHINE TOOL SALES LIMITED.— An order for machine tools to the value of £270,000 from the Bulgarian State Commercial enterprise "Machinoimport".

FERRANTI LIMITED. Hollinwood.—Bulk order from the Central Electricity Generating Board, worth over £2¼m., for 17 large transmission transformers.

FULLER ELECTRIC LIMITED, (Hawker Siddeley Group).—£2m. order from the Central Electricity Generating Board for 23 large capacity, high voltage transformers.

STAVELEY INDUSTRIES LIMITED.—£330.000 research and development contract for a general purpose fully tape-controlled machine tool by the Department of Scientific and Industrial Research.

VICKERS-ARMSTRONGS (South Marston) Limited.—Mechanisation equipment, for the Canadian Post Office.

RUBERY OWEN & Co. LIMITED, Darlaston. Foundry Equipment Division.—Orders for complete foundry moulding plants for export to the Far East and Eastern Europe.

INCANDESCENT LIMITED.—Melting plant recently installed in the British Transport Commission's locomotive iron foundry at Crewe.

DUNFORD & ELLIOTT PROCESS ENGINEERING Limited.—Order from Courtaulds Limited for the supply of rotary louvre equipment to dry and cool cellulose tri-acetate. This plant will form part of a complete factory to manufacture Tri-acetate Yarn under the £6m. contract recently negotiated by Courtaulds Limited with Techmashimport of the U.S.S.R.

LINCOLN ELECTRIC COMPANY LIMITED, Welwyn Garden City, Herts.—Order for 50 Lincoln SAE. 300 amp, portable diesel-engined welding sets received from Eddison Plant Limited, Grantham.

DORMAN LONG (Bridge & Engineering) Limited and Tees Side Bridge & Engineering Works Limited.—Contract worth approximately £2¼m. for the supply, delivery and erection of the structural steelwork in Eggborough Power Station for the Central Electricity Generating Board.

NORTH OF SCOTLAND HYDRO-ELECTRIC Board have placed further contracts valued at nearly £2½m. for the Cruachan pumped storage section of their Loch Awe scheme. The contract for the construction of the Cruachan dam has been awarded to William Tawse, Limited, Aberdeen, and that for the construction of the outfall works connecting the Cruachan pumped storage power station with Loch Awe has been awarded to Edmund Nuttal, Sons & Co. Limited. Marshal, Fleming & Co. Limited Motherwell, will supply and erect the cranes for the Cruachan power station.

CHRISTY AND NORRIS LIMITED, Chelmsford. —Order worth over £35,000 to install an Automatic formula production and mixing plant at the Hoghton, Preston, premises of Jerry Ingram and Son Limited, feed millers. The installation will incorporate the new Schugi cold molasses mixer.

QUALTER, HALL AND COMPANY LIMITED, Barnsley.—Supply of twin-track turntable for a surface mine car circuit to Portingssiepen colliery, near Essen, through Siemag of Nephen, Germany.

Business Developments

Company Acquisitions

DAVY-ASHMORE LIMITED has aquired the capital of John M. Moorwood Limited, Sheffield, roll manufacturers.

Trading Agreements

WICKMAN LIMITED, Coventry, have formed two new operating subsidiaries—Wickman Machine Tool Sales Limited, and Wickman Wimet Limited.

UNDER a licensing arrangement with Ets. H. Blanc of Paris, Airtech Limited, of Haddenham, Bucks. are to manufacture "Multi-Trans" running Gear, for use with their Aircon range of air transportable containers.

Agents and Distributors

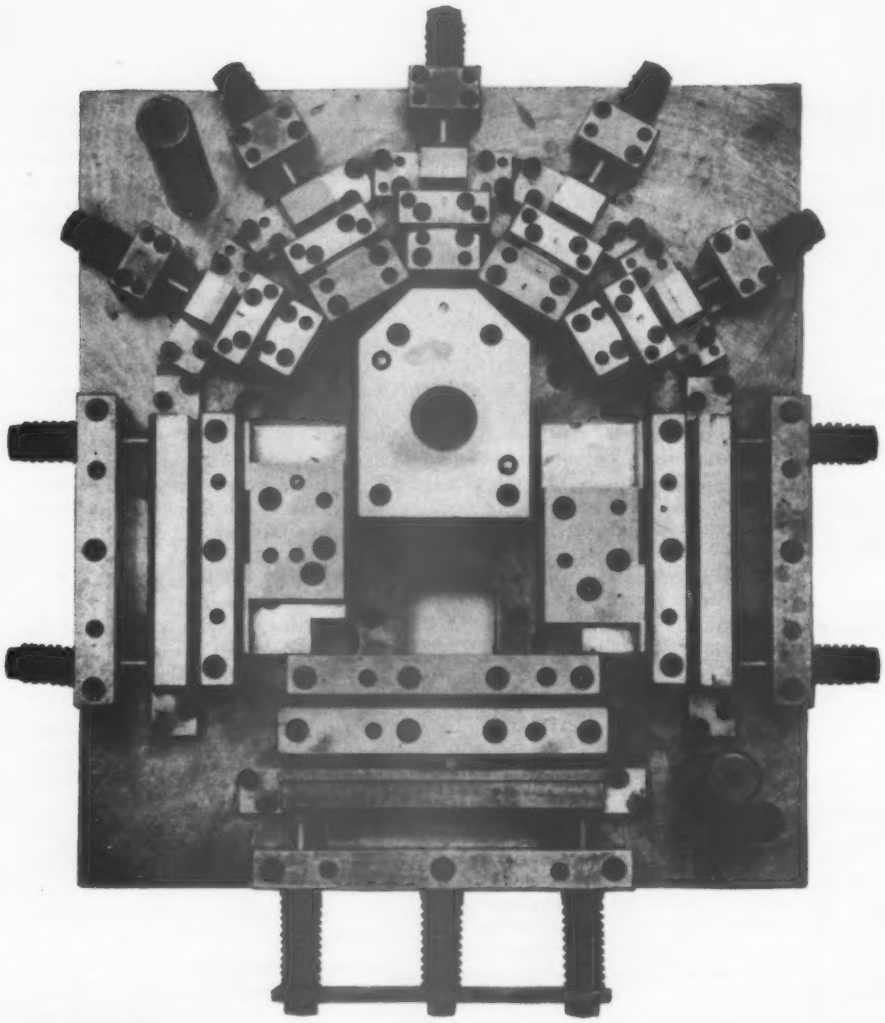
TIMES MACHINERY COMPANY LIMITED, Poyle Road, Colnbrook, Slough, Bucks, are now sole agents for the Beichle range of universal tool and die milling machines.

"Poly-V Drives"

NATIONAL COAL BOARD approval has now been given to the Poly-V drives manufactured by Turner Brothers Asbestos Company Limited, Rochdale. These belts have been officially tested for fire-resistant and anti-static properties in accordance with N.C.B. specification. Poly-V drives are already being used on equipment supplied to the National Coal Board.

Film News

Propane—the Modern Fuel. This new British Oxygen film illustrates some of many uses and advantages of propane as an industrial gas. A cartoon sequence shows how a complete factory runs on propane. Produced by Furlong Film Productions Limited, the film is a 16 mm. Ektachrome and runs for 18 minutes. Copies may be borrowed from: Film Librarian, The British Oxygen Company Limited, Technical Division, North Circular Road, Cricklewood, NW2.



K9 EDGAR ALLEN'S DIE STEEL

The illustrations show the die and finished product used as a container for an automatic playback tape recorder which is being issued to blind people. The box fits straight over a capstan on the tape deck which is accurately located by fixing lugs from the deck and close limits have to be maintained. The die is made of Edgar Allen's K9 die steel which has been perfected to meet the need for an inexpensive non-shrinking steel suitable for tools from which the highest accuracy is required. K9 will give long production runs with minimum regrinding. The die was designed and manufactured by P. & H. Metal Products (Kingston) Limited and has produced many thousands of containers.

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Cord, V- and Flat Belts

A new comprehensive catalogue of Turners Cord V-belts is available from Turner Brothers Asbestos Company Limited, Rochdale. The standard Turner belt has an outer extension zone of elastic rubber, high tensile pre-stretched synthetic fibre at the neutral axis and tough rubber to support the strength member and withstand the wedging action and a cover overall of hard wearing rubber-impregnated fabric, bias cut. In addition to the standard type the range includes belts of special qualities for particular applications. Complete technical data for belt selection are set out in the catalogue which also contains comprehensive drive tables for each section.

One of the mostly highly developed forms of belting is the whipcord flat belt. In this a row of rayon cord is wound continuously and the whole anchored in rubber and enclosed in a bias cut fabric envelope. Full particulars and design data are given in a further new Turner Brothers catalogue.

Ptfe Products

A new publication dealing with ptfe (polytetrafluoroethylene) has been issued by Turner Brothers Asbestos Company Limited, Rochdale. Fully comprehensive and detailing the range of ptfe products available, which includes impregnated asbestos and glass-fibre textiles, this booklet carries dimensional information of tubes, sheets, and tapes, as well as supplying complete specifications for machined components, gaskets, rings and packings. Two sections of this publication which will undoubtedly be useful to readers, are those dealing with the calculation of nominal weights for veneered tape (for which a nomograph has been included) and the section headed "Notes on ptfe Machining" which provides valuable information on drilling, finishing and bearing limitations etc. Copies of this publication are available on request to Turner Brothers Asbestos Company Limited, P.O. Box 40, Rochdale.

Solid Lubrication

A new information bulletin has just been published by Acheson Colloids Limited. Printed in three colours, this four page folder outlines the characteristics and principles of solid lubrication, with particular reference to the two main solids in the Acheson range, graphite and molybdenum disulphide. In the opening section, "Why Solids?", the limitations of fluid, and advantages of solid lubrication are discussed. This is logically followed by a review of the benefits to be derived from the use of these solids in *colloidal* form. Finally, the main uses of Acheson colloidal dispersions as plant and production process lubricants, parting agents and as electrically conducting coatings are summarised. Copies of the folder can be obtained from the Information Department, Acheson Colloids Limited, P.O. Box 12, Prince Rock, Plymouth, Devon.

Materials Handling

A new 28 page booklet has been published by Ensign Conveyor Company Limited, the Materials Handling Division of Thos. W. Ward Limited. This is a comprehensive booklet in two colours and fully illustrated. It provides a concise summary of the facilities of the Division and it is also a useful guide to some of the latest developments in individual items, and their application in the mechanical handling field. Copies are available from Ensign Conveyor Company Limited, Midland Works, Meadow Lane, Nottingham.

Trade Literature

Readers interested in any of the catalogues reviewed here can obtain copies by mentioning* MECHANICAL WORLD *when writing to the firms concerned.

Rocol Lubricants for the Marine Engineer

Notes on the use of Rocol molybdenised lubricants for the marine engineer have been issued by Rocol Limited. General purpose lubricants of particular interest to the marine engineer are Rocol anti-scuffing paste, anti-scuffing oil, Molytone greases, and Molygear. Applications dealt with include winches, capstans, derricks, hatches, valves, pipe connectors, diesel engines, emergency equipment, turbines, boiler room, auxiliary equipment, steering and stabilisers, and radar. Copies of the notes and information on the use of these lubricants are obtainable from the manufacturers: Rocol Limited, Rocol House, Swillington, Leeds. Tel: Garforth 2261. Telex: Leeds 55249.

Gas Turbines for Power Generation

Details of a complete power station which can be supplied by Associated Electrical Industries are given in a new booklet, "A Gas Turbine Power Station"—which has been produced by the company. The station has a nominal rating of 15-20 MW, using three identical generating units. It can be built quickly in any part of the world to provide a reliable power supply either independently or to supplement an existing system. The booklet is available from the AEI Turbine Generator Division, Trafford Park, Manchester 17.

'Talking About Cutting Fluids'

This is the title of the service booklet on cutting fluids issued by Fletcher Miller Limited, Alma Mills, Hyde, Cheshire, the third edition of which has recently been issued. It provides users with information on cutting fluids so that they can obtain the maximum value from them in the machine shop. Originally published in 1960, this publication has been well received and the present edition incorporates quite a lot of new material. It is unique in its field. Copies are available to readers upon request to the company at the address given above.

Speed Matching for Variable Speed Gears

An illustrated folder from Carter Gears Limited, Thornbury Road, Bradford 3, gives details of the speed matching or ratio setting device for independent Carter hydraulic variable speed drives. The device is a compact unit which fits on top of the gear casing and which provides an accurate and convenient means of setting and holding a speed relationship between separately driven machine sections, even when the basic speed varies greatly.

Calendar

Craven Brothers (Manchester) Limited, of Vauxhall Works, Reddish, Stockport, have issued their annual calendar which commences with the month of July and is of the month-to-a-page turn-over type for hanging on the wall. Each of the twelve pages bears the preceding and succeeding as well as the current month, and also a photograph, the first showing an aerial view of the works and the others typical Craven machines.

Water Hardness Monitor

A leaflet from Electronic Switchgear (London) Limited, Willbury Way, Hitchin, Herts., describes the "Testamat" water hardness monitor. It makes tests automatically every 10 min and shows a green light while the water is soft and a red one when hardness occurs.

Teddington Products Directory

A new 24 page Products Directory is now available free on request from Teddington Autocontrols Limited, Sunbury-on-Thames, Middlesex. Sectionalized under appropriate headings the publication lists with a brief description the complete range of automatic control instruments manufactured by the company and simplifies the selection of technical data sheets.

Neoprene Gaskets for Curtain Walls

A folder from DuPont Company (United Kingdom) Limited, 76 Jermyn Street, London SW1, illustrates the application of curtain wall gaskets on some notable new buildings and shows briefly the method of installation.

When to Automate

A catalogue of this title from The Meaker Company, Nutley, New Jersey, U.S.A., won a top award recently. It is a guide to the consideration of automatic machinery for metal finishing and allied processes.

Continued on next page.

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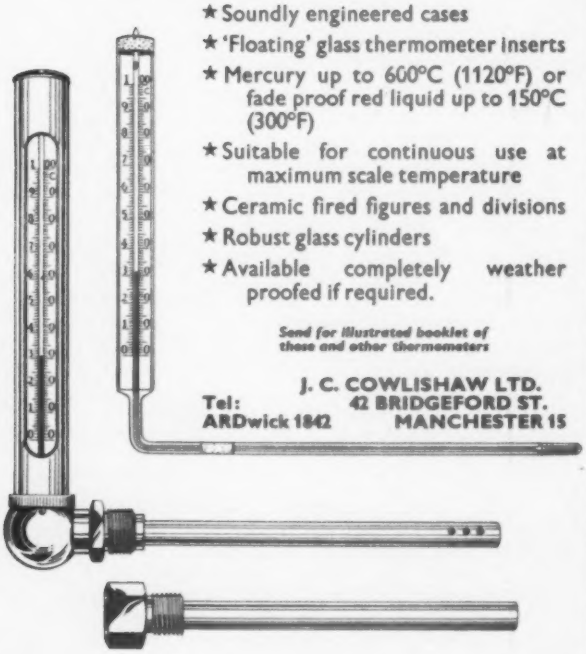

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TRADE LITERATURE—*Continued from previous page.*

Mobile Cranes

The various versions of the 511 mobile crane are clearly illustrated and described in a new catalogue from Ransomes & Rapier Limited, Ipswich.

Casting Equipment

A process for manufacturing intricate casting in lead and zinc alloys is fully described in a booklet from N. Saunders Metal Products Limited, 127 Munster Road, London SW6.

Heating Elements and Furnaces

Two new publications from Incandescent Limited, Cornwall Road, Smethwick, are an illustrated brochure on "Jetubes" for radiant tube heating, and a leaflet on their five sizes of furnaces for hardening high speed steel.

Whessoe Reconstructed

Highlights of the £4m redevelopment of the Darlington works of Whessoe Limited are recalled in a report by the main contractors, Bovis Limited. It is in the form of an illustrated brochure and shows how the reconstruction was carried out while the works were engaged fully on production.

Inert Gas Generators

A brochure in colour from W. C. Holmes & Co. Limited, Huddersfield, entitled "Generate Your Own Inert Gas" describes generators using either gas or oil fuel. Provision is made for separating the nitrogen and carbon dioxide if required.

Bedlington. Welwyn Electrical Laboratories. Plans have been prepared for factory addition on the Bedlington Station trading estate. No tenders have yet been obtained. The work will be carried out under the authority of the Industrial Estates Management Corporation, Team Valley, Gateshead. The architect is William Stockdale, F.R.I.B.A., 73 Howard Street, North Shields.

Billingham-on-Tees. Imperial Chemical Industries Limited, Billingham, are to extend one of their wharves on the River Tees by about 400 ft. The cost will be about £500,000.

Houghton-le-Spring. Industrial Estates Management Corporation, Team Valley, Gateshead. Plans have been prepared for factory additions.

Keswick (Cumberland). Miller (Great Yarmouth) Limited, Derwent Mills, Cockermouth, Cumberland, are planning a shoe making factory on a site at Low Brigham. Planning approval has been given in principle.

Newcastle-on-Tyne. Domestos Limited. Plans have been approved for factory additions at Albion Row. The architects are Cockett, Burns Dick and Mackeller, 21 Ellison Place, Newcastle.

Stockton-on-Tees. W. Cockburn and Company, Surtees Street, Stockton. Plans have been approved for a sheet metal workshop at Portrack Grange Road.

Ashmore, Benson Pease and Company Limited, Bowesfield Lane, Stockton, are to erect a plate shop of about 19,000 sq. ft.

Sunderland. Wear Glassworks Limited (J. A. Jobling and Company Limited.) Plans have been approved for a factory addition at Deptford. The contractors are D. and J. Ranken Limited, Stockton Road, Sunderland.

G. A. Balback. Plans are being prepared by F. B. Swainston, 28 Albert Road, Middlesbrough, for tyre depot, workshops, offices, etc., at William Street.

G. S. Stadler and Company (1920) Limited. The architects for a proposed tripe preparing factory at Hendon are Newrick and Blackbell, 58 John Street, Sunderland.

Washington (Co. Durham). Tube Investments Limited. Work has started preparing the 280 acres site for a new factory. The contractors for the preliminary work are R. M. Douglas Limited, Birmingham.

Accrington. Highams Limited, Woodnook Mills, Mount Street are to be extended.

Ashford. Proprietory Perfumes Limited, Grange Road, London. SE1. are to build a new factory.

Bracknell. Kellman Instruments Limited. New factory.

Brimsdown. Royal Limited. A new factory is to be built at Bilton Way.

Buckingham. The Buckingham Carpet Company Limited, are to extend their works at Lenborough Road.

Leslie Hartridge Limited, are to extend their works in Tingewick Road.

Cheltenham. Spirex-Sarco Engineering Limited. The factory at Tennyson Road is to be extended.

Coventry. General & Industrial Enamellers Limited, Torrington Avenue are to make extensions to their factory.

Croydon. Clifton Tools Limited, 36 Whitehorse Lane are to extend their factory.

Croydon Advertisers Limited, Overtons Yard are to erect a new printing works.

Dagenham. Distillers Company Limited, Chequers Lane are to erect an instrument workshop.

Dunstable. Yardley & Co. Limited, Carpenters Road, London E15 are to erect a new factory.

New Factories

Eastleigh. Pirelli-General Company Limited, are to extend their works at Dew Lane.

Edmonton. Kaye-Gibson Limited, Shaftesbury Road are to extend their works.

Farnham. Heath Bros. have applied for permission to extend their factory in East Street.

Hastings. Hastex Limited. A new factory is proposed at Hurrell Road.

Hull. Hull Steel Radiators Limited. The factory in Hedon Road is to be extended.

Hill Engineering Company Limited, are to extend their works at Beverley Road.

Inverness. J. Arthur Dixon Limited. The factory at Longman industrial estate is to be extended.

Kings Lynn. Unicam Instruments Limited, Arbury Road, Cambridge. Permission has been granted to erect a new factory at Hardwick Road trading estate.

Kirkintilloch. W. & A. Graham Limited, 24 Kilsyth Road are to build a new factory.

London. Harpham & Son Limited, Waterloo Road, London NW2. have applied for permission to erect a factory at Waterloo Road, Willesden.

Luton. Russell Sell Trading Company Limited. A light engineering factory is to be erected at Selbourne Road.

Manchester. J. C. Cowlishaw Limited, 42 Bridgeford Street. A new factory is to be built at Cawdor Street, Hulme.

Selas Gas & Engineering Company Limited. Extensions are to be made to Selas Works, City Road.

Newport (Mon). Thermalite Ytong Limited, Lea Marston, Sutton Coldfield are seeking permission to erect a new factory near Uskmouth power station.

Nottingham. Pearson Bros. (Nottingham) Limited. The factory at Upper Parliament Street is to be extended.

Nuneaton. Premier Artificial Stone Company Limited, Globe Works, Chapel End are to make extensions to their works.

Oxford. Hunt (Oxford) Limited, Broad Street are to lease a new site at Horspath Road industrial estate.

Pontardawe. Berlei (U.K.) Limited, Carlton House, Ebbw Vale are to erect a new factory.

Portsmouth. Walker Bros. (Printers) Limited, Maitland Street, Landport are to build a new works at All Saints Street.

Smethwick. A. E. Griffiths Limited. The factory in Rolfe Street is to be extended.

Payne & Griffiths Limited, are to make extensions to their Tudor Works, Windmill Lane.

Surbiton. Siebe Gorman & Company Limited. The factory in Davis Road is to be extended.

Ripley (Derbyshire) Berrey & Underwood Limited, Talbot Street. Nottingham. Permission is being sought to erect a new factory in Derby Road, Morehouse.

Thame. (Oxfordshire) British Oxygen Company Limited, Bridgewater House, Cleveland Row, London SW1. are seeking permission to erect a new factory.

Warrington. Peter Stubbs Limited. Approval has been received for extensions to Palatin Works, Wilderspool Causeway.

Watford. British Moulded Hose Limited, Sandown Road are to extend their factory. The architects are Ivan Nellist & Ian Blundell, 7 Dorchester Road, Northolt.

F. Darton & Co. Limited, 25 Watford Fields, Watford. A new scientific instrument works is to be built at Vale Road, Bushey.

Worthing. W. Whitehead Limited. The architect for the erection of a new factory at part of West Worthing Goods Yard is H. C. Wolledge, 66 Goring Road.

Clydebank. John Brown & Co., Clydebank are developing their West Yard, which when completed will be able to take tankers of 100,000 ton and over.

Glenrothes. The Beckman Instrument Limited plant at Glenrothes will be extended as soon as production needs demand; a further 3 acres of land have been opted adjoining the factory to meet this expansion.

Motherwell. Nuway Enamelling & Manufacturing Company, Birmingham, are now installing plant and machinery in their new factory at Carfin Industrial Estate, Motherwell. They plan to start production in late summer.

Perth. J. B. Butchart & Sons. Following negotiations the Perth Town Council are to erect a wireworks factory at a cost of £65,000.

Stonehaven. Mr. James S. Mitchell has received Kincardine County Council Industrial sub-committee recommendation for a factory at Cowie, Stonehaven for the production of car components. The plant would employ between 70 and 75 workers.

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PUMPS for all purposes. R.L. Christiansen Limited Wordesley, Stourbridge. Brierley Hill 78184/5.

Patents For Sale or License

THE proprietor of British Patent No. 794369, entitled "Net Handling Apparatus" offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 140 So. Dearborn Street, Chicago 3, Illinois U.S.A.

THE proprietor of British Patent No. 707617, entitled "Ejecting mechanism for punch presses", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 140 So. Dearborn Street, Chicago 3, Illinois, U.S.A.

THE proprietor of British Patent No. 791022, entitled "Improvements relating to retaining pins or pin fasteners", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 140 So. Dearborn Street, Chicago 3, Illinois, U.S.A.

THE proprietors of Patents No. 772927 for "Improvements in or relating to Bucket Wheel Excavators for excavating earth or the like". 785184 for "A Bucket Wheel Excavator for Excavating Earth or the like" and 785272 "Improvements in or relating to Bucket Wheel Excavators for Excavating Earth or the like", desire to secure commercial exploitation by license or otherwise in the United Kingdom. Replies to Box. No. L.W. 41, MECHANICAL WORLD, 31, King Street West, Manchester 3.

THE proprietor of British Patent No. 767755, entitled "Adsorption Device", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 140 South Dearborn Street, Chicago 3, Illinios, U.S.A.

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THE proprietor of British Patent No. 766260, entitled "Balanced Valve", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 140 South Dearborn Street, Chicago 3, Illinois, U.S.A.

THE proprietor of British Patent No. 772370, entitled Improvements in and Relating to Web Winding Cutters, offers same for license or otherwise to ensure its practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 770 Lexington Avenue, New York 21, New York, U.S.A.

THE proprietors of Patent No. 766508 for "Improvements in or relating to Hose Reel Units" desire to secure commercial exploitation by License or otherwise in the United Kingdom. Replies to Box No. KW 38 'MECHANICAL WORLD,' 31, King Street, West, Manchester, 3.

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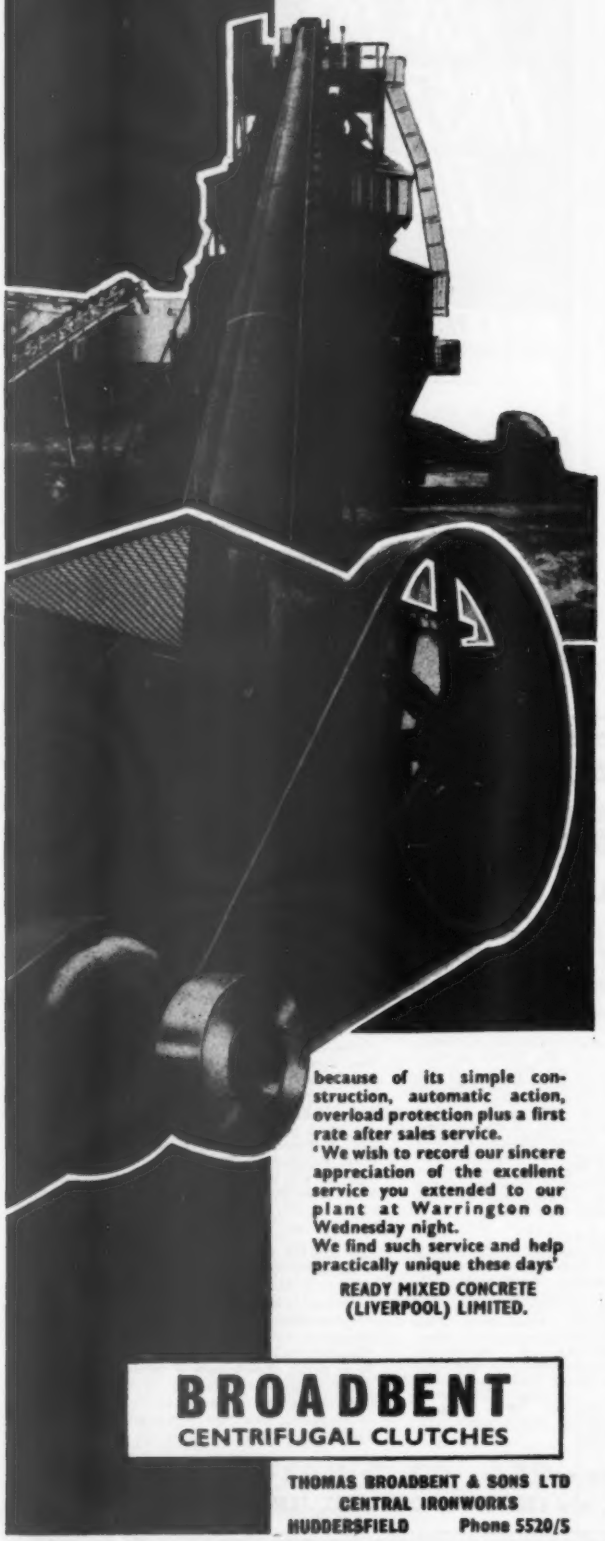

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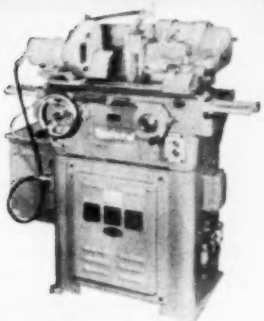

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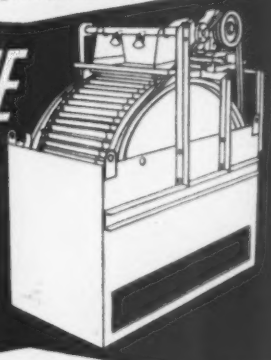

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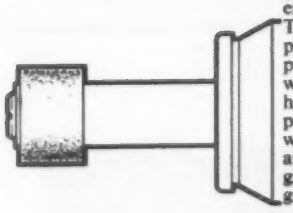

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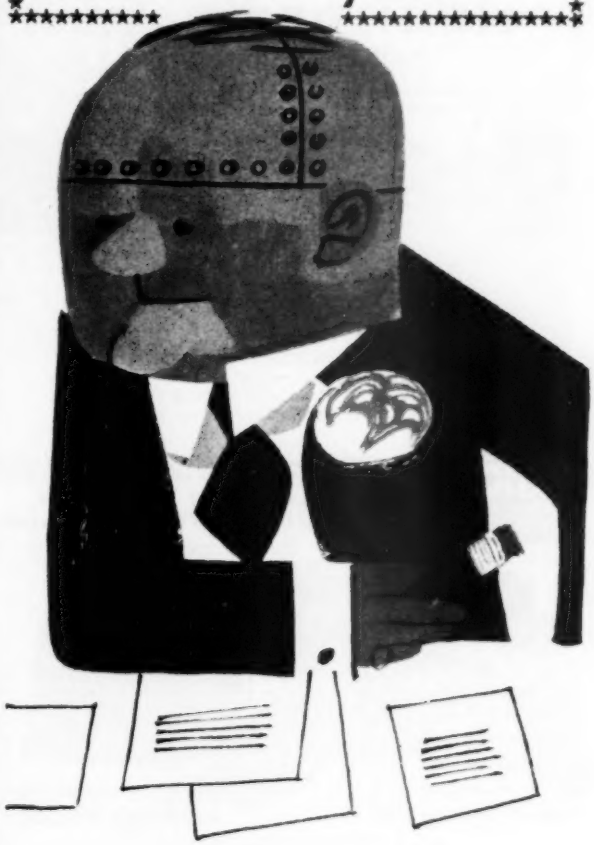

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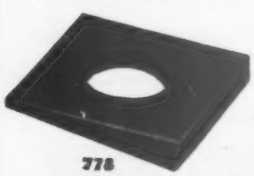

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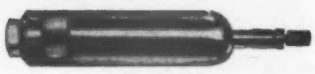

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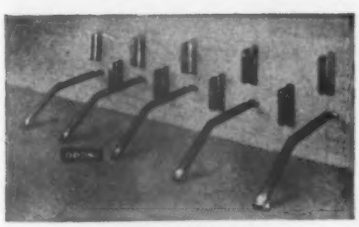

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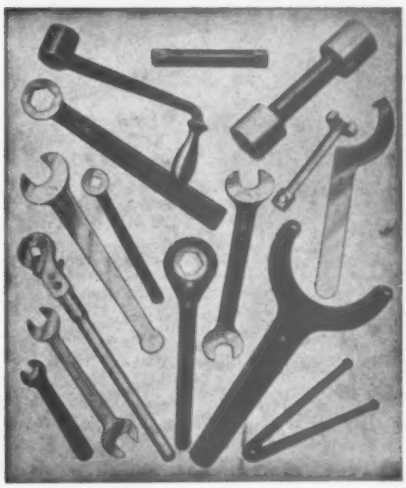

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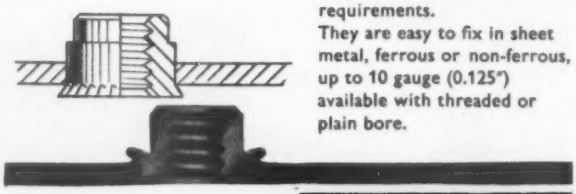

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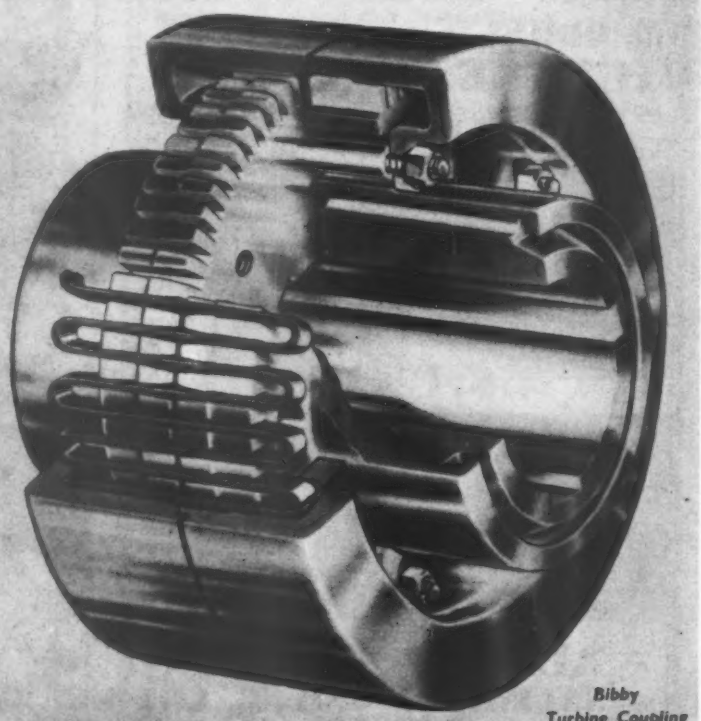

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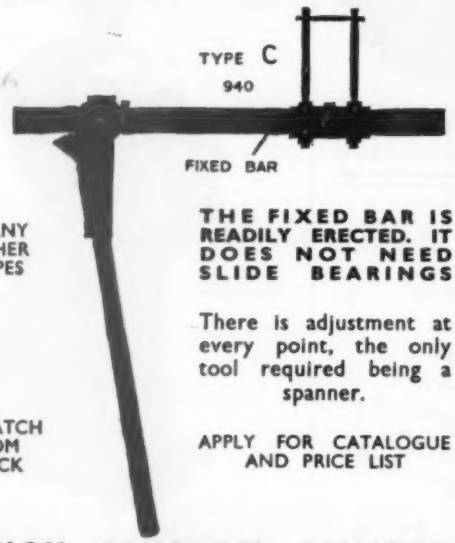

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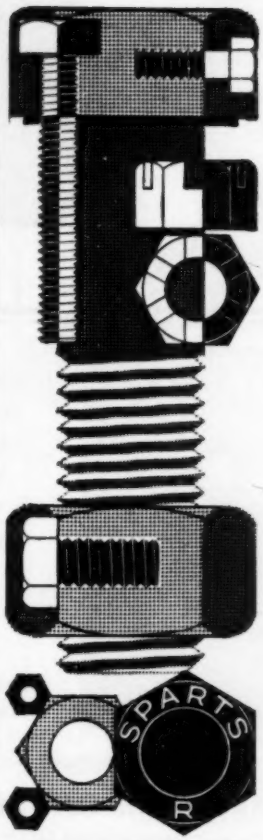

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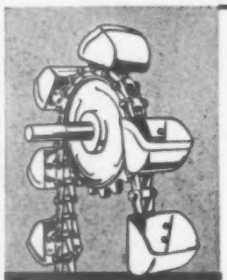

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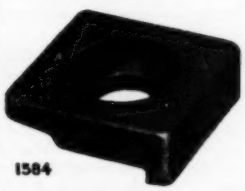

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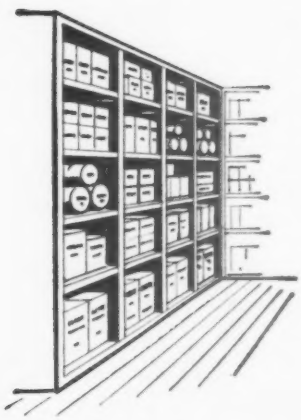

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